FINAL REPORT

To determine suitability of new green roof substrate mixes for use in Wallbarn's modular extensive green roof system

June 2020

STRI Research

CONTENTS

Summary	3
Trial A – Substrate Selection	
Materials and Methods	4
Treatments	4
Results	5
Trial B – Field Growth Trial	
Materials and Methods	6
Treatments	6
Assessments	7
Results	8
Discussion	15
Plates	16
Trial Plan	20

Summary

The objective of these trials was to determine suitability of new substrate mixes for use in Wallbarn's modular extensive green roof system. Concerns have been raised by Wallbarn over the current bulk density and high organic content of their current extensive green roof substrate mixture. Laboratory tests (J002501 & J002784) have identified a number of suitable new substrate mixtures which have lower organic content and lower bulk density than the current Wallbarn mixture.

Trial A assessed the suitability of new substrate mixtures in terms of laboratory tested bulk density. This trial highlighted that substrate mixtures needed to have at a maximum, 50% by volume organic matter if overall field capacity weight was to be reduced, and ideally less than 50%. Therefore, two of the substrate mixtures used in Trial B had 30 % organic matter. Substrates from Trial A, in addition to other substrate mixes were taken forward to Trial B.

Trial B was a full field trial lasting from July 2019 to May 2020. Substrate mixture 3 (25 % green waste compost, 25 % coir, 50 % LECA) consistently promoted the quickest and most even *Sedum* germination during the summer of 2019. This resulted in much greater, and better quality of *Sedum* coverage during the Autumn of 2019 and the Winter of 2020. By the end of May 2020, this treatment showed almost 100 % coverage, which was nearly two months in advance of the other treatments, which only reached full coverage by mid-July. However, for all substrate treatments, only four species of *Sedum* were observed during the trial. This may be worth considering as a topic for future research to understand which species don't germinate and the reason for this.

Bulk density tests showed that substrate number 3 was between 12-14 % lighter than the current Wallbarn substrate at field capacity, and in real terms 3 kg lighter per M-Tray.

In conclusion, this trial has shown that Wallbarn could use an alternative substrate mixture which would a) reduce the weight of trays by 12-14 % (3 kg), and also promote quicker and more even *Sedum* establishment. This translates into better *Sedum* coverage and allows trays to potentially be ready for installation significantly quicker than Wallbarn's current substrate mixture.

Trial A – Substrate Selection

Trial A was an initial laboratory screen of potential substrate mixtures for use in Wallbarn's M-Tray. Samples of each substrate were tested for physical characteristics, the most important being field capacity bulk density. Substrates to be taken forward to the next stage of field testing were required to have a lower field capacity bulk density compared to Wallbarn's existing substrate.

Materials and Methods

Field site : The trial was carried out within STRI soils laboratory, Bingley (GPS reference 53.8474 and -1.8579).

Timing : Substrate samples were mixed and tested in May 2019.

Experimental design : Two replicates of each substrate sample were tested for the following parameters: oven dry bulk density, field capacity bulk density.

Treatments

Table 1-Trial A substrate treatment mixtures

Mixture	GW Compost	Coir	Pumice	LECA (clay)	Lytag 4-8 mm	Lytag 0-4 mm CC	Lytag 8-16 mm
[1] Lytag 4-8mm	25	25			50		
[2] Pumice 1	25	25	50				
[3] Pumice 2 + Lytag 0-4mm CC	25	25	25			25	
[4] LECA 1	25	25		50			
[5] LECA 2+ Lytag 0-4mm CC	25	25		25		25	
[6] Lytag 4-8mm + Lytag 0-4mm CC	25	25			25	25	
[7] Lytag 0-4 mm CC	25	25				50	
[8] Current Wallbarn Substrate	50	25					50

Results

Physical properties

Substrate mixtures 3 and 4 had lower field capacity bulk density compared to the current Wallbarn mixture (Table 2). This was in part due to a lower water holding capacity, as well as lighter component parts within the substrate. Substrate 1, 2 and 5 all had similar field capacity bulk density to the current Wallbarn mixture.

The decision was therefore taken to further reduce levels of organic matter even further for Trial B mixtures, as well as use combinations of pumice, LECA and Lytag. The chosen substrate mixtures for Trial B are shown in Table 3.

Table 2-Physical properties of Trial A substrate treatment mixtures

Mixture	Bulk Density g cm^{-3} (oven dried)	Bulk Density g cm^{-3} (when received)	Bulk Density g cm^{-3} (field capacity)	Field Capacity %
[1] Lytag 4-8mm	0.59	0.85	1.23	58
[2] Pumice 1	0.58	0.84	1.26	58
[3] Pumice 2 + Lytag 0-4mm CC	0.36	0.53	0.85	49
[4] LECA 1	0.49	0.73	1.07	55
[5] LECA 2+ Lytag 0-4mm CC	0.72	0.99	1.27	53
[6] Lytag 4-8mm + Lytag 0-4mm CC	0.89	1.21	1.63	70
[7] Lytag 0-4 mm CC	0.73	0.96	1.41	59
[8] Current Wallbarn Substrate	0.52	-	1.22	63

Trial B – Field Growth Trial

Trial B was a field trial of selected substrates and the current Wallbarn substrate. The trial aimed to look at establishment of Wallbarn's *Sedum* seed mixture in Wallbarn M-Trays over the course of a growing season at STRI's trial ground, Bingley, UK.

Materials and Methods

Field site : The trial was carried out at STRI research facilities, Bingley (GPS reference 53.8474 and -1.8579). The trial took place on a flat area, with the substrate in Wallbarn's current green roof M-Tray modules.

Timing : The trial began in early July 2019 and ran until May 2020.

Experimental design : The trial was set up as a randomised complete one-way block design. Five treatments with five replications were set up to make a total of 25 trays.

Treatments

Table 3 – Trial B (field trial) substrate treatment mixtures

Substrate Mixture	GW Compost	Coir	Pumice	LECA (clay)	Lytag 4-8 mm	Lytag 0-4 mm CC	Lytag 8-16 mm
[1] LECA & Pumice 1	25	25	25	25			
[2] LECA & Pumice 2	15	15	35	35			
[3] LECA	25	25		50			
[4] LECA & Lytag	15	15		35		35	
[5] Current Wallbarn Mixture	25	25					50

Trays were seeded with *Sedum* seed (0.5g m^{-2}) in line with current Wallbarn production methods on 02.07.20. A medium coarse sand carrier was used to assist seed sowing. Trays received fertiliser and other management treatments in line with current Wallbarn production standards. Trays were irrigated throughout the trial as necessary, and to best replicate current Wallbarn production methods.

Fertiliser Applications:

02.07.19 – Calcium ammonium nitrate per tray (1 kg m^{-3}/6.75 g m^{-2})
02.09.19 – Calcium ammonium nitrate @ 50 g m^{-2}
14.04.20 - Calcium ammonium nitrate @50 g m^{-2}

An additional two trays were filled with extensive green roof substrate provided by Shire Green Roof Substrate and seeded on 01.08.19. Maintenance practices were the same as trial trays from this point onwards.

Assessments

Sedum Germination

The amount of *Sedum* germination on each tray was visually assessed using a 1-10 scale where 1 = no germination visible, 5 seedlings easily visible from standing and 10 = full germination and even coverage across each tray. Assessments were made on a regular basis after sowing until full germination had occurred by late August 2019.

Sedum Coverage

The coverage of *Sedum* seedlings was visually assessed as % coverage. Coverage of individual *Sedum* species were identified. Assessments was made fortnightly during the 2019 growing season once germination had occurred. An additional assessment was conducted in May 2020.

Sedum Quality

The quality of sedum was assessed on a 1-10 scale where 1 = no or dead *Sedum* plants, 5 = acceptable *Sedum* quality and 10 = excellent *Sedum* quality. Assessments was made fortnightly during the 2019 growing season once germination had occurred. An additional assessment was conducted in May 2020.

NDVI

NDVI of each module was taken using a handheld Trimble Greenseeker NDVI meter. An average reading was taken across each tray. Assessments was made fortnightly during the 2019 growing season once germination had occurred. An additional assessment was conducted in May 2020.

Weed Infestation

The number of weeds in each tray was counted and a % coverage area of weed also assessed. Assessments was made fortnightly during the 2019 growing season once germination had occurred. An additional assessment was conducted in May 2020.

Substrate Height from Tray Edge

The substrate height in each tray was measured by laying a straight edge across the width of the tray and measuring using a ruler the difference between the edge and the height of substrate in five locations. Assessments took place once during the trial.

Tray weight

The saturated weight of each tray was assessed on one occasion during the trial. Trays were saturated using a hose and left to drip dry for 2 hours once dripping has finished. Trays were then individually weighed.

Sedum Species Identification

The composition of *Sedum* seedlings within each module were visually identified down to species level. Assessments were made three times throughout the trial once seedlings were identifiable. Shannon-Weiner Index values were also calculated from species composition values.

Full BS8616 specification

A full BS8616 green roof substrate test will be conducted on the chosen substrate at the end of the trial. Substrate will be chosen in co-ordination with Wallbarn.

Results

Sedum Germination

Significant differences in *Sedum* germination scores were observed on three out of four assessments dates (Table 4). On these dates Treatment 3 had significantly better germination (greater number of seedlings and more even distribution) than all other treatments. Differences among treatments were no longer observed by late August 2019, 56 days after sowing.

Sedum Coverage - Overall

Significant differences in *Sedum* coverage were observed on six out of seven assessments dates (Table 5). Coverage of *Sedum* in Treatment 3 trays was consistently greater than all other treatments throughout the trial, with differences still visible in May 2020. *Sedum* coverage among all other treatments (Treatments 1, 2, 4 and 5) did not significantly differ from one another throughout the trial.

Sedum Coverage -Species Composition

A total of four *Sedum* species were identified on all treatment plots, *S. acre, S. spurium, S. album* and *S. reflexum* (Table 6). On all three assessment dates, the coverage of *S. reflexum* was significantly greater on Treatments 3, 4 and 5 plots compared to Treatments 1 and 2. In late November the coverage of *S. album* was significantly greater on Treatment 2 and 3 plots compared to all other treatments. This effect was no longer present in May 2020. The coverage of *S. acre* and *S. spurium* did not significantly differ among treatments on any assessment date. The majority of *Sedum* coverage was made up of *S. spurium* (12-28 %) and *S. album* (22-41 %) for all treatments with *S. acre* (0.4-3.8 %) and *S. reflexum* (3.6-9.6 %) making a smaller contribution for all treatments.

Sedum Quality

Significant differences in *Sedum* quality were observed on five out of six assessments dates (Table 7). Quality of *Sedum* in Treatment 3 trays was consistently greater than all other treatments throughout the trial, with differences still visible in May 2020. *Sedum* quality among all other treatments (Treatments 1, 2, 4 and 5) did not significantly differ from one another throughout the trial.

NDVI

Significant differences in NDVI scores were observed on all six assessment dates (Table 8). NDVI scores were significantly the greatest on Treatment 3 plots compared to all other treatments throughout the trial. Among all other treatments (Treatments 1, 2, 4 and 5), consistent differences were not observed during the trial.

Weed Infestation – Area coverage

No significant differences in weed coverage among treatments were observed at any point during the trial (Table 9).

Weed Infestation – Number of weeds

There were no significant differences in number of weeds among treatments at any point during the trial (Table 10).

Substrate Height from Tray Edge

The substrate height in all trays settled during the trial and was below the edge of M-Tray on the assessment date on 20.11.19 (Table 11). The greatest level of settlement was observed for Treatment 1, 3 and 5, and Treatment 4 showing the lowest level of settlement.

Tray weight

Significant differences existed in tray weight among treatments (Table 11). Lightest trays were Treatment 3 and the heaviest Treatment 2 and 4.

***Sedum* Species Identification**

There were no significant differences among treatments for Shannon-Weiner Index scores and for number of *Sedum* species (Table 12). Shannon-Weiner Index scores were low for all treatments, reflecting the low number of species identified during the trial. A total of four *Sedum* species were identified on all treatments by the end of the trial.

Full BS8616 specification

Data to be provided separately upon agreement with Wallbarn on chosen substrate.

Visual observations of Shire Green Roof Substrate Trays

Sedum species were slow to establish on these trays, with visual observations indicating that the substrate seemed to dry out very quickly on the surface leading to crust like layer. When germination did occur, species identified seemed to be entirely *Sedum album*, with only a few observed *S. reflexum* and *S. spurium* observed.

Full coverage of the tray was observed in July 2020, although coverage was still predominantly *S. album*.

Table 4: Germination of *Sedum* on a 1-10 scale where 1 is no germination observed, 5 is seedlings are easily visible from standing and 10 is full germination and even coverage across plot. DAS = Days after sowing.

Treatment	11.07.19 9DAS	18.07.19 16DAS	07.08.19 36DAS	27.08.19 56DAS
[1] 25% GW Compost, 25% Coir, 25% Pumice, 25% LECA	1.6 b	2.0 a	2.6 a	2.6
[2] 15% GW Compost, 15% Coir, 35% Pumice, 35% LECA	1.2 ab	2.0 a	2.8 a	3.2
[3] 25% GW Compost, 25% Coir, 50% LECA	2.4 c	2.8 b	3.8 b	3.8
[4] 15% GW Compost, 15% Coir, 35% LECA, 35% Lytag 0-4mm CC	1.2 ab	2.0 a	2.6 a	2.8
[5] 50% GW Compost, 25% Coir, 25% Lytag 8-16mm	1.0 a	2.0 a	3.0 a	3.4
P	<0.001	0.012	0.011	NS
LSD	0.58	0.50	0.69	-
d.f.	16	16	16	16
%c.v.	29.1	17.3	17.4	22.2

*NS = Not significant.

Table 5: % Area covered by *Sedum* in trial plot. DAS = Days after sowing.

Treatment	16.09.19 76DAS	04.10.19 94DAS	17.10.19 107DAS	31.10.19 121DAS	20.11.19 141DAS	29.05.20 332DAS
[1] 25% GW Compost, 25% Coir, 25% Pumice, 25% LECA	6	10 a	24 a	24 a	22 a	55 a
[2] 15% GW Compost, 15% Coir, 35% Pumice, 35% LECA	6	13 a	21 a	21 a	22 a	51 a
[3] 25% GW Compost, 25% Coir, 50% LECA	14	39 b	50 b	51 b	50 b	81 b
[4] 15% GW Compost, 15% Coir, 35% LECA, 35% Lytag 0-4mm CC	6	6 a	14 a	14 a	14 a	45 a
[5] 50% GW Compost, 25% Coir, 25% Lytag 8-16mm	9	17 a	22 a	24 a	24 a	61 a
P	NS	0.003	0.005	0.007	0.009	0.005
LSD	-	15.2	17.5	18.6	18.7	17.9
d.f.	16	16	16	16	16	16
%c.v.	62.5	66.1	49.9	51.8	53.0	22.8

*NS – Not significant

Table 6: % Area covered by each identifiable *Sedum* species in trial plot. DAS = Days after sowing.

Treatment	*% Sedum acre*			*% Sedum spurium*			*% Sedum album*			*% Sedum reflexum*		
	16.09.19 76DAS	20.11.19 141DAS	20.05.20 332DAS	16.09.19 76DAS	20.11.19 141DAS	20.05.20 332DAS	16.09.19 76DAS	20.11.19 141DAS	20.05.20 332DAS	16.09.19 76DAS	20.11.19 141DAS	20.05.20 332DAS
[1] 25% GW Compost, 25% Coir, 25% Pumice, 25% LECA	0.6	1.2	1.6	2.4	8.0	18.0	2.2	11.8 a	32.0	0.4 a	1.0 a	3.6 a
[2] 15% GW Compost, 15% Coir, 35% Pumice, 35% LECA	0.4	0.4	0.0	2.4	4.2	12.2	2.2	15.2 ab	33.6	0.6 ab	1.8 a	5.2 a
[3] 25% GW Compost, 25% Coir, 50% LECA	0.8	1.2	3.8	6.8	18.4	27.6	4.6	26.8 b	40.6	1.8 c	3.8 b	9.4 b
[4] 15% GW Compost, 15% Coir, 35% LECA, 35% Lytag 0-4mm CC	0.4	0.4	0.4	2.4	4.6	15.0	1.4	6.8 a	22.0	1.4 bc	2.6 ab	7.2 ab
[5] 50% GW Compost, 25% Coir, 25% Lytag 8-16mm	1.0	1.4	3.0	3.4	5.0	13.6	3.4	14.2 a	34.6	1.2 abc	2.4 ab	9.6 b
P	NS	NS	NS	NS	NS	NS	NS	0.04	NS	0.023	0.044	0.017
LSD	-	-	-	-	-	-	-	12.27	-	0.88	1.75	3.90
d.f.	16	16	16	16	16	16	16	16	16	16	16	16
%c.v.	112.1	146.2	178.2	89.9	106.2	40.4	79.3	61.2	40.4	61.1	56.4	41.0

*NS – Not significant

Table 7: *Sedum* quality on a 1-10 visual scale. *Sedum* quality incorporates *Sedum* health, *Sedum* species variation, evenness of species and area covered by *Sedum*. DAS = Days after sowing.

Treatment	16.09.19 76DAS	04.10.19 94DAS	17.10.19 107DAS	31.10.19 121DAS	20.11.19 141DAS	29.05.20 332DAS
[1] 25% GW Compost, 25% Coir, 25% Pumice, 25% LECA	3.2	3.1 a	3.4 a	3.4 a	3.4 a	4.6 a
[2] 15% GW Compost, 15% Coir, 35% Pumice, 35% LECA	3.4	3.4 a	3.2 a	3.2 a	3.0 a	4.8 a
[3] 25% GW Compost, 25% Coir, 50% LECA	4.4	5.7 b	6.0 b	6.0 b	5.2 b	7.4 b
[4] 15% GW Compost, 15% Coir, 35% LECA, 35% Lytag 0-4mm CC	2.6	2.6 a	2.6 a	2.8 a	2.8 a	3.8 a
[5] 50% GW Compost, 25% Coir, 25% Lytag 8-16mm	3.6	3.9 a	3.4 a	3.6 a	3.4 a	5.0 a
P	NS	0.006	0.005	0.003	0.014	0.007
LSD	-	1.53	1.66	1.53	1.37	1.80
d.f.	16	16	16	16	16	16
%c.v.	26.6	30.6	33.3	30.0	28.6	25.7

*NS – Not significant.

Table 8: Normalised Difference Vegetation Index (NDVI) determined using a Trimble Greenseeker Meter (0.00-0.99 scale). A higher score represents a higher coverage. DAS = Days after sowing.

Treatment	16.09.19 76DAS	04.10.19 94DAS	17.10.19 107DAS	31.10.19 121DAS	20.11.19 141DAS	29.05.20 332DAS
[1] 25% GW Compost, 25% Coir, 25% Pumice, 25% LECA	0.25 a	0.47 bc	0.43 ab	0.47 ab	0.46 a	0.53 a
[2] 15% GW Compost, 15% Coir, 35% Pumice, 35% LECA	0.19 a	0.41 ab	0.35 a	0.46 ab	0.47 a	0.56 a
[3] 25% GW Compost, 25% Coir, 50% LECA	0.42 b	0.66 d	0.74 c	0.74 c	0.76 b	0.75 b
[4] 15% GW Compost, 15% Coir, 35% LECA, 35% Lytag 0-4mm CC	0.19 a	0.36 a	0.33 a	0.33 a	0.38 a	0.52 a
[5] 50% GW Compost, 25% Coir, 25% Lytag 8-16mm	0.36 b	0.54 c	0.54 b	0.52 b	0.54 a	0.57 a
P	<0.001	<0.001	<0.001	<0.001	0.003	0.008
LSD	0.091	0.101	0.135	0.141	0.171	0.126
d.f.	16	16	16	16	16	16
%c.v.	24.0	15.4	21.0	20.8	24.3	16.1

*NS – Not significant

Table 9: % Area of weed coverage of trial plot. DAS = Days after sowing.

% Weed Area	27.08.19 56DAS	16.09.19 76DAS	04.10.19 94DAS	17.10.19 107DAS	31.10.19 121DAS	20.11.19 141DAS	29.05.20 332DAS
[1] 25% GW Compost, 25% Coir, 25% Pumice, 25% LECA	4	4	4	4	4	1	0.1
[2] 15% GW Compost, 15% Coir, 35% Pumice, 35% LECA	5	3	2	4	6	3	0.1
[3] 25% GW Compost, 25% Coir, 50% LECA	5	4	2	2	3	0	0.2
[4] 15% GW Compost, 15% Coir, 35% LECA, 35% Lytag 0-4mm CC	6	3	2	3	4	2	0.1
[5] 50% GW Compost, 25% Coir, 25% Lytag 8-16mm	11	7	3	2	1	1	0.0
P	NS	NS	NS	NS	NS	NS	NS
LSD	-	-	-	-	-	-	-
d.f.	16	16	16	16	16	16	16
%c.v.	73.5	79.9	58.6	114.3	148.9	118.3	273.9

*NS = Not significant.

Table 10: Average number of weeds in each trial plot. DAS = Days after sowing.

Number of Weeds	27.08.19 56DAS	16.09.19 76DAS	04.10.19 94DAS	17.10.19 107DAS	31.10.19 121DAS	20.11.19 141DAS	29.05.20 332DAS
[1] 25% GW Compost, 25% Coir, 25% Pumice, 25% LECA	3	4	47	13	12	3	0.2
[2] 15% GW Compost, 15% Coir, 35% Pumice, 35% LECA	3	3	40	16	14	12	0.4
[3] 25% GW Compost, 25% Coir, 50% LECA	3	4	31	4	5	1	0.4
[4] 15% GW Compost, 15% Coir, 35% LECA, 35% Lytag 0-4mm CC	3	2	37	12	9	9	0.2
[5] 50% GW Compost, 25% Coir, 25% Lytag 8-16mm	8	6	28	8	5	4	0.0
P	NS	NS	NS	NS	NS	NS	NS
LSD	-	-	-	-	-	-	-
d.f.	16	16	16	16	16	16	16
%c.v.	91.6	85.5	65.2	104.5	122.7	141.4	268.4

*NS – Not significant

Table 11: Substrate height from tray edge (mm). Measured in five spaces across each tray and averaged for each tray. A negative number represents substrate being below the edge of the tray. Measured weight of each tray (kg) is also displayed. DAS = Days after sowing.

Treatment	Substrate Height (mm)	Tray Weight (kg)
	20.11.19	20.11.19
	141DAS	141DAS
[1] 25% GW Compost, 25% Coir, 25% Pumice, 25% LECA	-19 a	20.5 b
[2] 15% GW Compost, 15% Coir, 35% Pumice, 35% LECA	-9 bc	23.1 c
[3] 25% GW Compost, 25% Coir, 50% LECA	-15 ab	18.1 a
[4] 15% GW Compost, 15% Coir, 35% LECA, 35% Lytag 0-4mm CC	-3 c	22.9 c
[5] 50% GW Compost, 25% Coir, 25% Lytag 8-16mm	-13 ab	21.1 b
P	0.03	<0.001
LSD	9.7	1.30
d.f.	16	16
%c.v.	62.8	4.7

Table 12: Calculated Shannon-Weiner index using % area of each species in each tray. Number of species of *Sedum* present in each tray are also displayed. DAS = Days after sowing.

Treatments	Shannon-Weiner Index			Number of Species		
	16.09.19	20.11.19	29.05.20	16.09.19	20.11.19	29.05.20
	76DAS	141DAS	332DAS	76DAS	141DAS	332DAS
[1] 25% GW Compost, 25% Coir, 25% Pumice, 25% LECA	0.93	0.94	0.90	2.8	3.4	3.2
[2] 15% GW Compost, 15% Coir, 35% Pumice, 35% LECA	0.98	0.89	0.83	3.0	3.4	3.0
[3] 25% GW Compost, 25% Coir, 50% LECA	1.10	0.95	1.00	3.4	3.4	3.4
[4] 15% GW Compost, 15% Coir, 35% LECA, 35% Lytag 0-4mm CC	1.02	1.06	0.99	3.0	3.2	3.2
[5] 50% GW Compost, 25% Coir, 25% Lytag 8-16mm	1.10	0.91	0.96	3.6	3.2	3.2
P	NS	NS	NS	NS	NS	NS
LSD	-	-	-	-	-	-
d.f.	16	16	16	16	16	16
%c.v.	22.1	20.1	16.2	22.2	13.8	8.6

*NS – Not significant.

Discussion

The objective of the trial was to determine suitability of new substrate mixes for use in Wallbarn's modular extensive green roof system. A key requirement was to reduce the bulk density of the substrate compared to the existing Wallbarn mixture, without compromising *Sedum* establishment and growth.

Trial A assessed the physical properties of a number of alternative substrate mixes, in order to choose a number to take forward to a field trial in the Summer of 2019. This trial highlighted that if the substrate mixture was to have a lower bulk density the substrate mixture needed to have at a very maximum 50% by volume organic matter, and ideally less than this. Therefore, the decision was taken to reduce the amount of organic matter down to 30% by volume on a number of the mixtures in the field trial.

The field trial in Trial B was conducted from July 2019 to May 2020, with the majority of assessments occurring in the Autumn of 2019. Substrate mixture 3 (25 % green waste compost, 25 % coir, 50 % LECA) consistently promoted the quickest and most even *Sedum* germination during the summer of 2019. This then translated into much greater, and better quality of *Sedum* coverage during the Autumn of 2019 and the Winter of 2020. By the end of May 2020, this treatment showed almost 100 % coverage, with the trays in a condition which would allow them to be installed on a roof. This was a good two months in advance of the other treatments which only reached full coverage by mid-July.

Bulk density tests in the lab showed that substrate mix number 3 was 12% lighter than the current Wallbarn mix at field capacity. Field testing of trays at field capacity showed a similar reduction in weight of 14 %, which results in trays being reduced by 3 kg.

In general, only four species of *Sedum* were observed on all substrate treatments in the first growth season. This may be due to the growing conditions in this trial or point to the inherent poor germination success of some *Sedum* species. Further research would be advised to trial different germination methods to improve germination success of all *Sedum* species. The additional Shire Green Roof substrate trialled showed good germination coverage, but with only one main *Sedum* species germinating. This may be due to the presence of very fine particles in substrate which seemed to form a slight crust on the surface once it dried out. This may have prevented certain species of *Sedum* from successfully germinating.

In conclusion, this trial has shown that Wallbarn could use an alternative substrate mixture which would a) reduce the weight of trays by 12-14 % (3 kg), and also promote quicker and more even *Sedum* establishment. This translates into better *Sedum* coverage and allows trays to potentially be ready for installation significantly quicker than Wallbarn's current substrate mixture.

Plates

Plate 1: Trial site with mixed substrate before plot randomisation

Plate 2: Trial site after plot randomisation and installation of protective wooden edging

Plate 3: Trial site on 29.08.19 (58DAS). *Sedum* seeding just visible with weed ingress

Plate 4: Trial site on 29.08.19 (58DAS). *Sedum* seeding just visible with weed ingress

Plate 5: Trial site on 29.08.19 (58DAS). *Sedum* seeding just visible with weed ingress

Plate 6: Trial site on 23.10.19 (113DAS) with significant differences visible among treatments

Plate 7: Treatment 1 on 21.11.19 (142DAS)

Plate 8: Treatment 2 on 21.11.19 (142DAS)

Plate 9: Treatment 3 on 21.11.19 (142DAS)

Plate 10: Treatment 4 on 21.11.19 (142DAS)

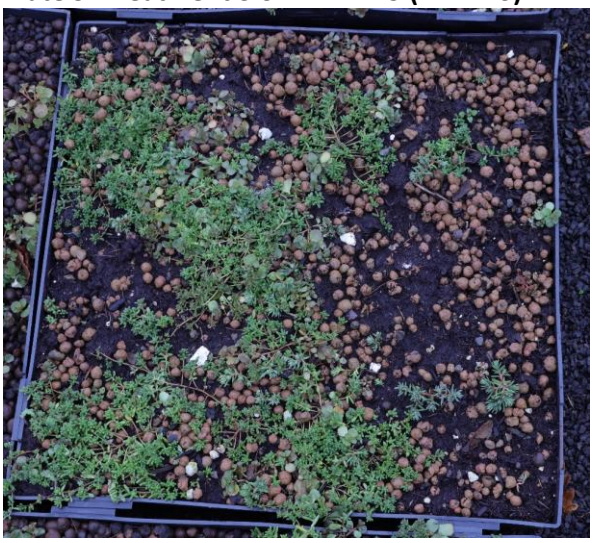


Plate 11: Treatment 5 on 21.11.19 (142DAS)

Plate 12: Treatment 1 on 04.06.20 (142DAS)

Plate 13: Treatment 2 on 04.06.20 (142DAS)

Plate 14: Treatment 3 on 04.06.20 (142DAS)

Plate 15: Treatment 4 on 04.06.20 (142DAS)

Plate 16: Treatment 5 on 04.06.20 (142DAS)

Plate 20: Trial site on 24.01.20 (206DAS)

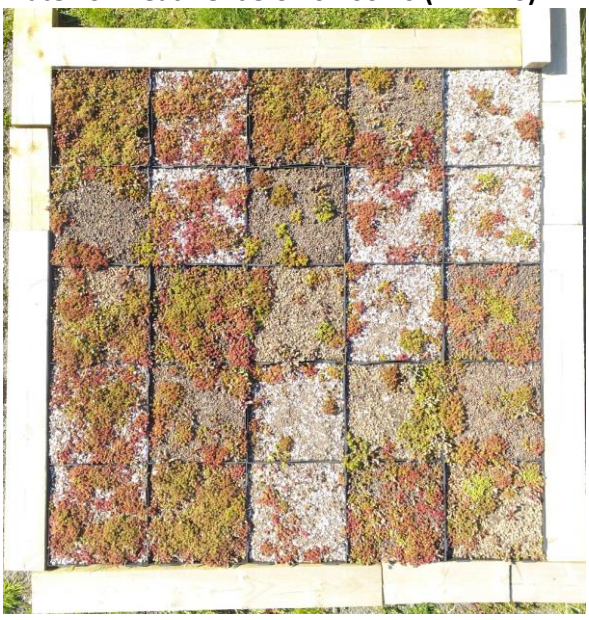


Plate 21: Trial site on 24.04.20 (297DAS)

Plate 22: Trial site on 06.05.20 (309DAS)

Plate 23: Trial site on 30.06.20 (364DAS)

Plate 24: Trial site on 20.07.20 (384DAS)

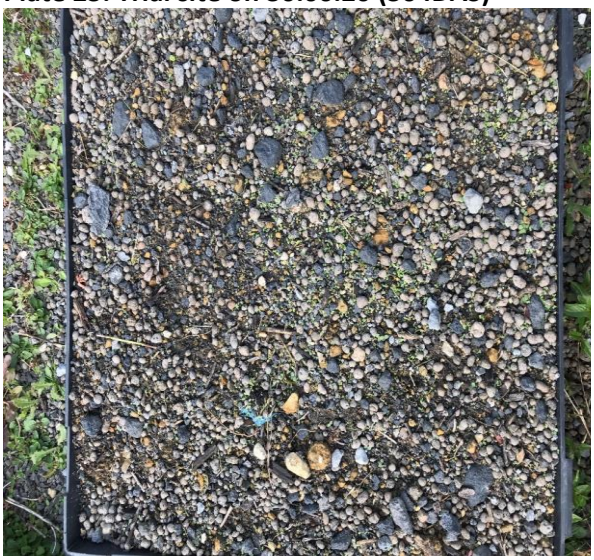


Plate 25: Shire Green Roof Substrate on 22.08.20 (21DAS) with seedlings emerging

Trial Plan

Block 1	Block 2	Block 3	Block 4	Block 5
3	1	3	4	2
4	2	4	2	1
5	3	5	1	3
2	4	1	5	4
1	5	2	3	5

Treatments	% Composition
[1] Pumice + Lytag 0-4mm CC	25% GW, 25% Coir, 25% Pumice, 25% Lytag 0-4mm CC
[2] Pumice + Lytag 0-4mm CC B2	15% GW, 15% Coir, 35% Pumice, 35% Lytag 0-4mm CC
[3] LECA	25% GW, 25% Coir, 50% LECA
[4] LECA + Lytag 0-4mm CC	15% GW, 15% Coir, 35% LECA, 35% Lytag 0-4mm CC
[5] Wallbarn Current Mix	50% GW, 25% Coir, 25% Lytag 8-16mm.

Signed:  **(Study Director)**

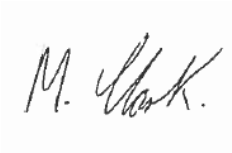
Date: 28 July 2020

Please ensure that your Sales/Marketing Department is aware that this research has been carried out under contract and that the consent of STRI must be obtained where information contained in the report is to be used in advertising or promotional literature.

QUALITY STATEMENT

We confirm that this report is a true representation of the original data collected and that the Standard Operating Procedures referred to in the STRI Manual of Standard Operating Procedures, and those relevant to data collection, data preparation, archiving of data and preparation of reports have been implemented in full.

Prepared by:  **(28 July 2020)**

Checked by:  **(28 July 2020)**

Final version checked and reviewed by:  **(10 August 2020)**

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