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Electrical Weed Control of Docks

Final Report

Date: 30 November 2021

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GENERAL NOTES

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Author	Lynn Tatnell	**Technical reviewer**	Sarah Cook
			
Date:	07/01/22	Date:	06/01/22
Innovation Broker	Will John	**Quality reviewer**	Sarah Cook
			
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About EIP-AGRI

The European Innovation Partnership for Agricultural productivity and Sustainability (EIP-AGRI) was launched by the European Commission in 2012. It aimed to foster a competitive and sustainable agriculture and forestry sector that "achieves more from less". It contributed to ensuring a steady supply of food, feed and biomaterials, and to the sustainable management of the essential natural resources on which farming and forestry depend, working in harmony with the environment.

EIP Wales

Menter a Busnes delivers the EIP Wales scheme on behalf of the Welsh Government and has received funding through the Welsh Government Rural Communities – Rural Development Programme 2014-2020, which is funded by the European Agricultural Fund for Rural Development and the Welsh Government.
For Welsh farm and forestry businesses to remain competitive, profitable and resilient, they will need to work on a continuous programme of improving both business and technical practices.
The aim of EIP Wales was to solve common agricultural and forestry problems by bringing people from practical and scientific backgrounds together. It was an opportunity for farmers and foresters to put their ideas into practice by testing new technologies or techniques.

This project evaluated innovative new technology which can be used to control docks in grassland systems in Wales. Docks (*Rumex* spp.) are a major problem in Welsh grassland systems. Infestation can reduce grass yields and utilisation through competition for light, moisture and nutrients. This project aimed to test whether such novel practical methods can be used as a realistic alternative to herbicides, or in conjunction with herbicides for integrated weed management.

EIP Operational group

The businesses represented in the operational group are:

Organisation	**Name**	**Farm/Location**	**Role**
	Rob Jones	Llwyncelyn, Penrhos, Raglan	Lead Farmers & principal contact
	Ross Edwards	New Dairy Farm, Newport NP10 8SF	Farmer
	David Peter Evans	*Argoed Farm, Great Oak, Llanarth*	*Original Lead Farmer*
Field Options	Francis Dunne	Field Options Unit 3 Broadaxe Business Park, Presteigne Powys LD8 2UH	Actor

Other members of the project

Organisation	**Name**	**Location**	**Role**
RSK ADAS Ltd	Lynn Tatnell	ADAS SCW ADAS Boxworth, Battlegate Road,	Principal Research Scientist- Weed Biology

		Boxworth, Cambridgeshire CB23 4NN	
RSK ADAS Ltd	Kevin Godfrey	ADAS SCW ADAS Rosemaund, Preston Wynne Herefordshire HR1 3PG	Research Scientist – Weed Biology
RSK ADAS Ltd	Aldwyn Clarke	ADAS SCW Canolafan Enterprise Park Llanafan Ceredigion SY23 4AY	Senior Scientist Field crop assessments
RSK ADAS Ltd	Will John	ADAS ALM Henstaffe Court Business Centre, Groesfaen, Cardiff CF72 8NG	Innovation Broker

EXECUTIVE SUMMARY

The aim of this project was to evaluate innovative new technology to control docks in grassland systems in Wales. An electrical weeder was trialled in grass fields, over a period of two years, on three dairy farms in south Wales which were suffering from a dock infestation (*Rumex* spp.). Electrical treatments were compared with a control of no intervention and a conventional herbicide.

Docks are a major problem in Welsh grassland systems. Infestation can reduce grass yields and utilisation through competition for light, moisture and nutrients. Docks are less palatable than grass and can also reduce silage quality as docks have only 65% of the feed value of grass. The use of herbicide sprays to control docks in pasture can have a negative effect on clover and implications for the wider catchment ecosystem if used incorrectly. This project seeks to test whether novel non-chemical control methods can be used as a realistic alternative to herbicides, or in conjunction with herbicides for integrated weed management. A reduction in the use of herbicides in grassland would be of benefit in terms of water quality, whilst the ability to manage docks and maintain clover levels in swards would be of additional benefit to farmers, reducing overall nitrogen application rates.

Overall results from these trials have concluded that electrically treating dock plants on three treatment timings was very effective, in terms of dock removal and can be equivalent to a herbicide application alone. It must be considered that the economics of the systems has not been assessed in these trials, as tractor-mounted kit was not available for testing and therefore the hand-held kit would have different running costs. Electrical control is extremely promising as an additional tool for dock management in grassland, that would benefit organic farmers or those requiring lower herbicide inputs. It could also help to retain clover in the sward as it is more of a spot treatment if used when the height of the dock plants is above the sward.

Feedback from the host-farmers proved their interest in the technology and that they saw great scope for the future if the kit could be tractor-mounted. They were particularly interested in the fact they could potentially retain more clover in a sward by using this type of technology to patch treat the weeds in a field compared to an overall herbicide spray that may result in loss of clover.

Electrical control of docks in grassland has been shown to be a very effective integrated management method for weed control. The tractor-mounted system is urgently required for uptake of this technology into the grassland market for it to be a commercially viable option.

CONTENTS

1 INTRODUCTION AND AIM

Docks (*Rumex* spp.), particularly broad-leaved (*Rumex obtusifolius*) and curled dock (*Rumex crispus*) and their hybrids, are perennial weeds and a major problem in Welsh grassland systems. Infestation can reduce grass yields and utilisation through competition for light, moisture, and nutrients. They have rapid growth potential and a high fecundity rate, particularly in high nutrient situations. Docks are less palatable than grass and can also reduce silage quality as docks have only 65% of the feed value of grass. The use of herbicides to control docks can have a negative effect on clover in pasture (as many herbicides can kill clover as-well so are referred to as non-clover safe) and implications for the wider catchment ecosystem if used incorrectly.

The aim of this project was to evaluate innovative new technology to control docks in grassland systems in Wales. A machine developed by Ubiqutek (now 'Rootwave') was utilised over a period of two growing seasons (within specific trialling months) to control docks by electrical destruction on dairy farms in south Wales. Electrical treatments were compared to conventional herbicide applications and untreated control areas. Dairy farms tend to have high nutrient status and reducing nitrogen inputs (lower nutrient status can assist in reducing dock populations) on the fields is not feasible.

1.1 Introduction to the field sites

All three farms were in south Wales.

The farmers were keen to host the field trial sites and provided fields with a good dock population that was being grazed during the trial period. Each farmer was actively involved in the project and contributed to steering meeting discussion and planning.

1.1.1 Argoed Farm

Argoed Farm is a grass based dairy unit, located near Llanarth, Monmouth (see **Figure 1**). Annual rainfall for the area taken from Manner NPK is 1,018 mm per annum. The project location is 50 metres above sea level. Soil type from soil maps indicates that the field is on the boundary of the Milford Association, a freely draining, fine loamy soil. Aspect is westerly. The farm had previously been managed as an organic dairy unit. Due to a change in tenancy, the farm could not be used in year two of the trial.

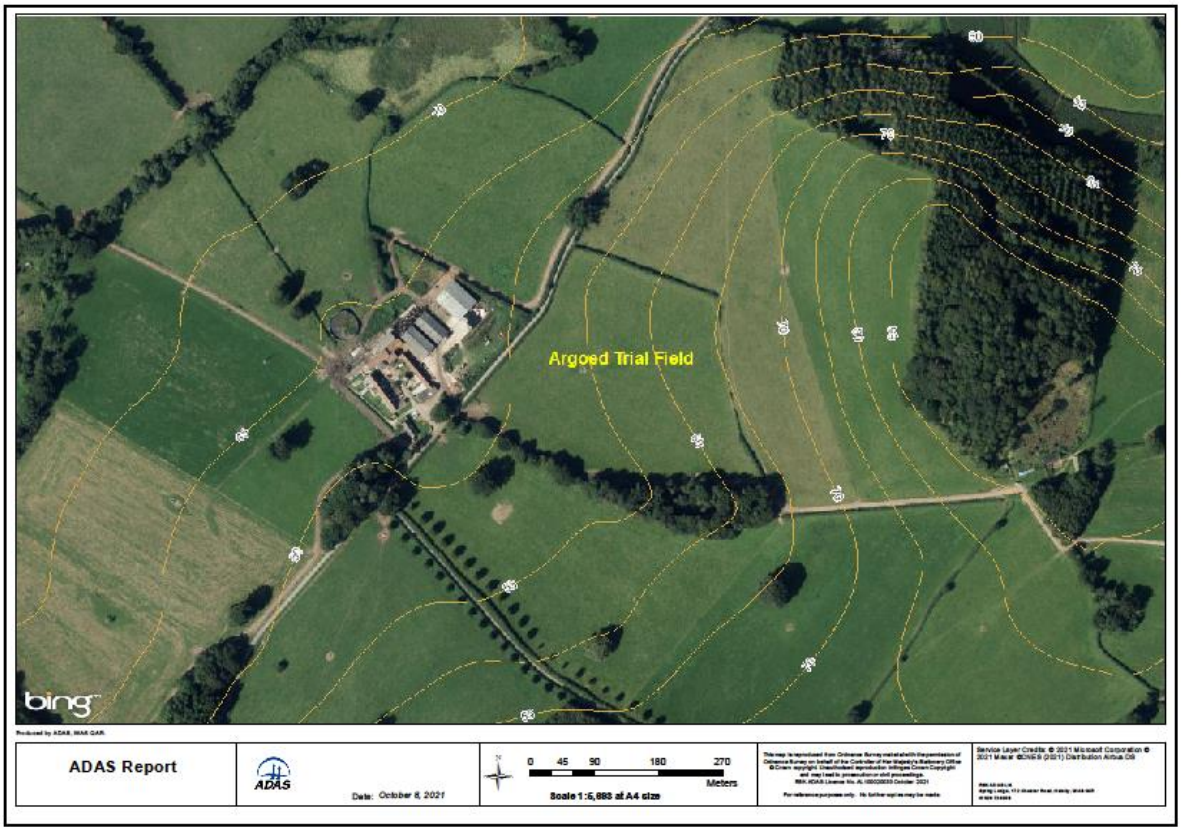

Figure 1. Aerial imagery of Argoed Farm showing topography

1.1.2 Llwyncelyn Farm

Llwyncelyn Farm is a mixed dairy and arable unit, located near Llanarth (**Figure 2**). Annual rainfall for the area taken from Manner NPK is 1,018 mm per annum. The project location is 80 metres above sea level. Soil type from maps indicates that the fields are of the Milford Association, a freely draining, fine loamy soil. Aspect is south-easterly. This site was used for both years of trials.

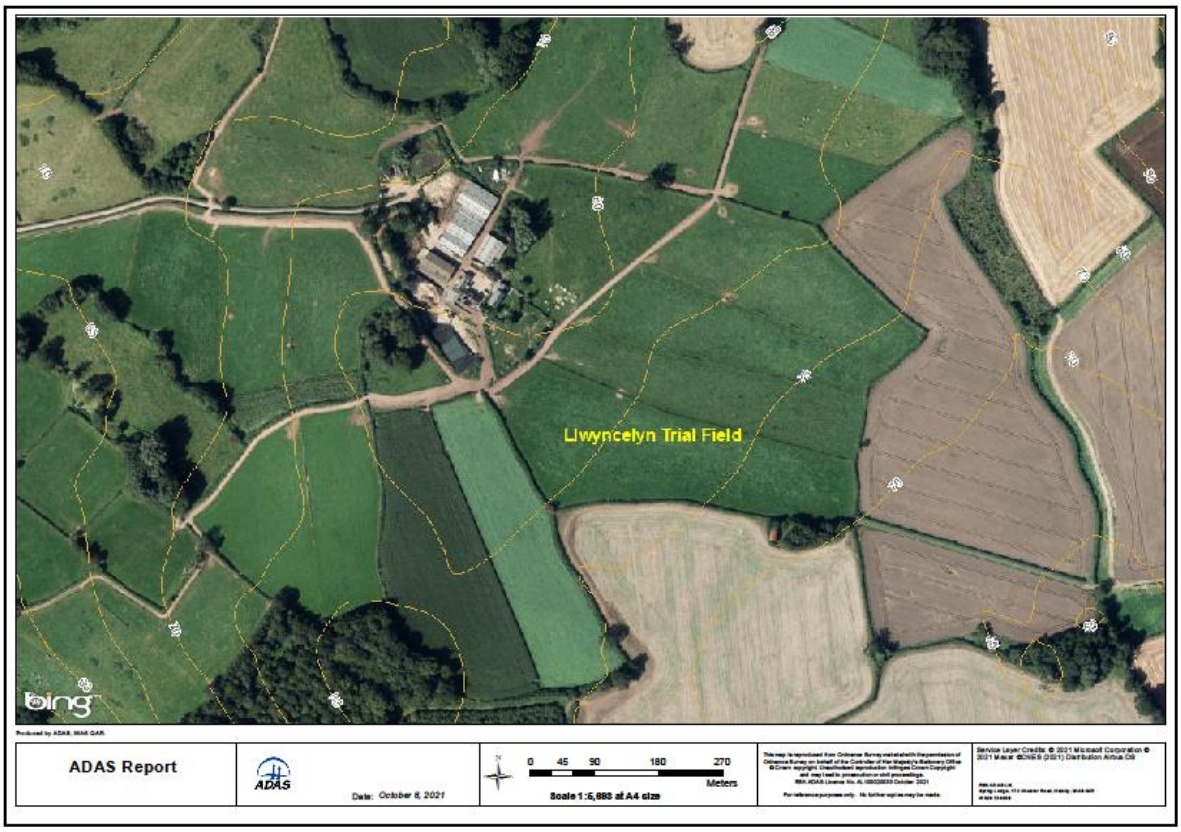

Figure 2. Aerial imagery of Llwyncelyn Farm showing topography.

1.1.3 New Dairy Farm

New Dairy Farm is a mixed dairy unit, located near Newport (**Figure 2**). Annual rainfall for the area taken from Manner NPK is 1,076 mm per annum. The project location is at 5-10 metres above sea level. Soil type from maps indicates that the fields are of the Newchurch 2 Association, a seasonally wet deep clay over river tidal formed alluvium. The ground is flat. The farm is located within an area known as the Gwent Levels which is subjected to artificial drainage schemes, and the area is criss-crossed by drainage channels, known locally as 'reens'. Ross Edwards from New Dairy has a keen interest in grassland management methods and was happy to join the project for the second year of trials.

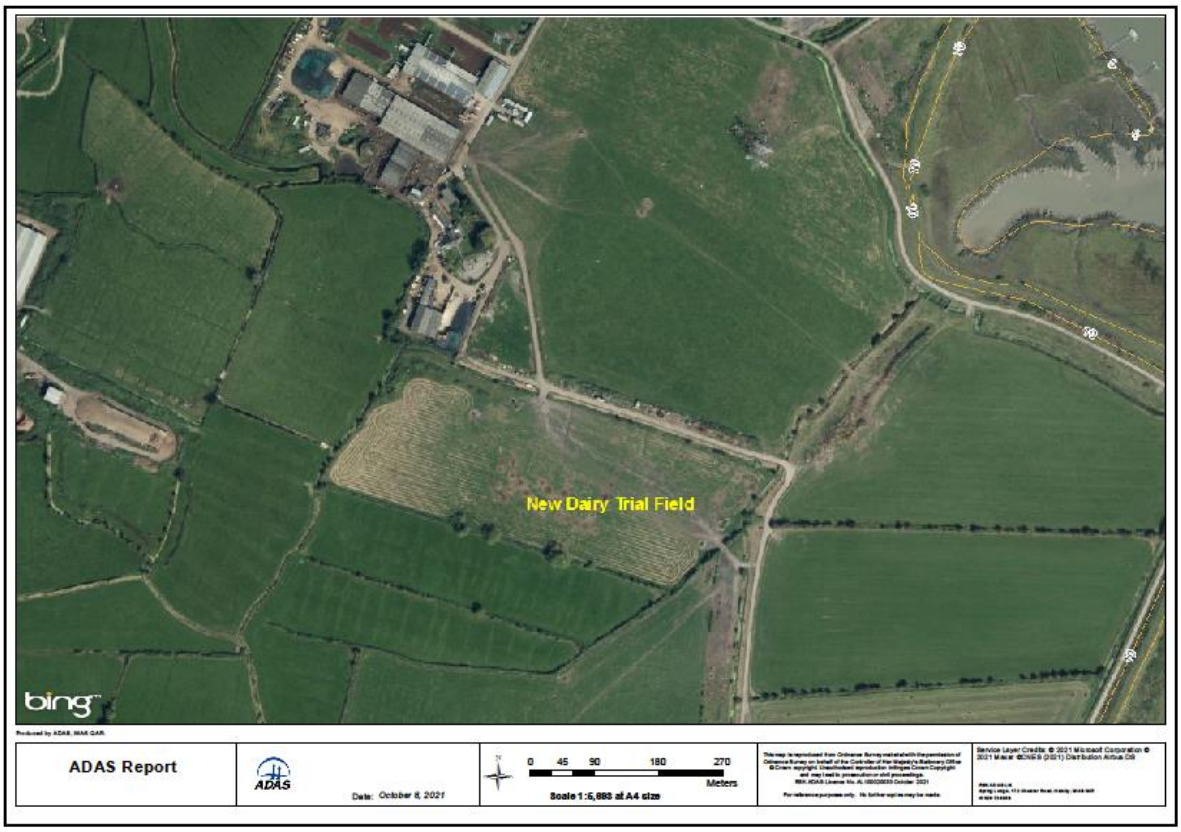

Figure 3. Aerial imagery of New Dairy Farm showing topography.

2 METHODOLOGY

2.1 Experimental design and treatments

The experimental design and implementation were led by ADAS, procured in line with Welsh Government (WG) protocols in conjunction with the host farmers and the electrical weeding system provider.

A 'Rootwave Pro' electrical weeding system was hired over a period of two growing seasons (within specific trialling months of February/March-June) to control docks by electrical destruction in selected paddocks. The machine was unfortunately not a tractor-mounted system as there was no option for this in the UK, therefore a hand-held lance was used to deliver the electrical charge to the dock plants by walking through the plots on foot in these trials. Electrical treatments were compared to conventional herbicide applications and an untreated control area (Table 1).

The treatments were carried out on Llwyncelyn Farm and Argoed Farm in the first year (2019) and Llwyncelyn Farm and New Dairy Farm in the final year (2021) on one field at each site. Each treatment was replicated three times in a randomised block design.

2.1.1 Field plots

Plots measuring 6m x 2m were marked out in an area of the field with a moderate to high natural population of docks. Due to the uneven patchy nature of weed growth there was a target of a minimum of 10 dock plants per plot to ensure good representation of the species in the plots. The four outer corners of the trial were marked with small metal pegs pushed into the ground (so they did not get eaten by the cattle when they return to the field!). On the day of treatments and assessments plastic pegs were used to define the plots for ease of applications and assessment. The plastic pegs were always removed before any cattle re-entered the field.

2.1.2 Experimental year one (2018-19)

The proposed six treatments were as follows:

1. Electrical treatment **once** in spring
2. Electrical treatment **twice** (2nd treatment ideally 3-4 weeks after the first timing, to be decided depending on the growing season, weed infestation level and practicality)
3. Electrical treatment **three times**, 3rd treatment 3-4 weeks after 2nd treatment timing
4. A conventional herbicide application
5. A combination of electrical treatment (once) and conventional herbicide,
6. No intervention (untreated control area)

In experimental year one, dock emergence was monitored during early spring and all plots were marked out in early May 2019 as the ideal growth stage had been reached on both sites, Llwyncelyn and Argoed farms. The actual treatments were then applied on the dates listed in Table 1.

Table 1 Treatment list for experimental year one

Treatment no.	Treatment description	Application timing	Date of application
T1	Electrical treatment x 1	Timing 1	20/05/19
T2	Electrical treatment x 2	Timing 1 & Timing 2 (4 weeks apart)	20/05/19 + 18/06/19
T3	Electrical treatment x 3	Timing 1, timing 2 and Timing 3 (further 2-4 weeks later)	20/05/19 + 18/06/19 + 15/07/19
T4	Conventional herbicide	Timing 2 only	20/05/19
T5	Electrical treatment x1 (T1) + Conventional herbicides (at T2)	Timing 1 -electrical Timing 2 - conventional	20/05/19 + 18/06/19
T6	Untreated control		n/a

Electrical treatment application

All electrical treatments were applied by trained staff from Rootwave. The Rootwave Pro machine used a generator (located in the back of a truck) and hand-held lance with a long (~20m) cable containing the electrode. Each dock plant in a plot was touched with the charged lance for approximately 5-10 seconds before moving on to the next plant.

Herbicide treatment application

The herbicide Doxstar Pro (fluroxypyr + triclopyr) was applied @ 2.0 l/ha in 300 l/ha of water using a knapsack sprayer and 2m hand-held boom in T4 and T5 (Table 1) on 20 May 2019 by ADAS.

Figure 3 Photo examples of the trials in spring 2019. Top L: field plot markers; Top R: The electrical weeder 'Rootwave Pro' kit in the truck; Bottom L: Lance treating a dock plant; Bottom R: Close up of lance treating dock plants.

Assessments

All plots were assessed for number of docks per plot pre- and post-treatment. Assessments were carried out by two people on each occasion taking a mean of the two counts. The assessments ended on 30 July 2019 as it was considered that all treatment effects were visible and plants were naturally senescing in the untreated plots, and no further assessment were needed in this trial year.

Table 2 Assessment timings year one (both sites)

Assessment required	Actual timing
Pre-treatment (day of treatment)	20/05/19
Two weeks after treatment (WAT) timing 1	29/05/19
Four WAT timing 1	18/06/19
Eight WAT timing 1, four WAT timing 2	15/07/19
Six WAT timing 2, two WAT timing 3	30/07/19

Photos were taken at each assessment, along with a record of the dock growth stages and any other symptoms.

All field sites continued with their normal grazing or topping regimes, and these were recorded.

2.1.3 Experimental year two (2020-21)

There was a delay of a year on the experiments due to COVID-19 restrictions. Experimental year two therefore became spring 2021. The treatment list was adjusted slightly from year one, as it was agreed by the project steering group that one electrical treatment alone was not robust enough. Therefore, the following treatment plan was proposed for year two (Table 3).

Table 3 The proposed treatment list for experiment year two

Treatment	Proposed timing- adjusted from year one	Treatment description
1	Mid-late April (T1) + (T2) 4-6 weeks later	Electrical treatment **x2** (T1 + T2)
2	T1, T2 and (T3)- a further 4-6 weeks after (late June)	Electrical treatment **X3** (T1 + T2 + T3)
3	Mid-late April (T1) + herbicide 4-6 weeks later	Electrical treatment **x1** (T1) + conventional herbicides (T2)
4	Herbicide late May-early June + electrical late June	Conventional herbicides (T2) + Electrical treatment **x1** (T3)
5	Optimal timing for dock growth stage (May-June)	Conventional herbicide alone (T2)
6		Untreated control

The treatments were successfully applied to both sites on the dates shown in Table 4 and Table 5.

Table 4 Treatment timings for Llwyncelyn site

Treatment	Treatment description	Date applied
1	Electrical treatment **x2** (T1 + T2)	29/04/21 + 03/06/21
2	Electrical treatment **X3** (T1 + T2 + T3)	29/04/21 + 03/06/21 + 15/07/21
3	Electrical treatment **x1** (T1) + conventional herbicides (T2)	29/04/21 04/06/21
4	Conventional herbicides (T2) + Electrical treatment **x1** (T3)	04/06/21 15/07/21
5	Conventional herbicide alone (T2)	04/06/21
6	Untreated control	-

Table 5 Treatment timings for New Dairy farm

Treatment	Treatment description	Date applied
1	Electrical treatment **x2** (T1 + T2)	05/05/21
2	Electrical treatment **X3** (T1 + T2 + T3)	05/05/21 + 04/06/21 + 16/07/21
3	Electrical treatment **x1** (T1) + conventional herbicides (T2)	05/05/21 04/06/21
4	Conventional herbicides (T2) + Electrical treatment **x1** (T3)	04/06/21 16/07/21
5	Conventional herbicide alone (T2)	04/06/21
6	Untreated control	-

The electrical treatment was applied using the same equipment as year one, although on treatment timing one (29 April 2021, Llwyncelyn and 05 May 2021, New Dairy farm) a trowel-shaped electrode was used on the end of the lance and for all subsequent treatments a hook-shaped electrode was used. The herbicide treatment was the same as experimental year one (section 2.1.2).

Grazing regime

At Llwyncelyn, the field plots were grazed a few days after the 1st electrical treatment at the end of April and again (lightly) in early June, a few days prior to the 2nd electrical treatment timing. The field was then grazed again in late June and mechanically topped in the first few days of July (before the final electrical treatment).

At New Dairy farm, the field plots had been grazed hard before the first treatment timings on 05 May 2021. No grazing of the trial area occurred between treatment timing one and two, and it was noted that the dock stems had started to elongate. The site was grazed between 11 to 26 June 2021, slurry had been applied and the field had also been mechanically topped. On the final treatment timing of 16 July 2021 there was a grazing herd of 25-30 heifers in the field.

Assessments

The percentage ground cover prior to any treatment was assessed on 29 April 2021, Llwyncelyn and 05 May 2021 New Dairy farm. Subsequent assessment dates are shown in Table 6 and Table 7, which included a percentage dock ground cover at both sites and an additional count of the number of dock plants per plot at each timing at Llwyncelyn only. The plant count was carried out as the number of dock plants was at a low enough threshold to count accurately.

Table 6 Assessment timings for Llwyncelyn site year two

Assessment required	Actual timing
Pre-treatment (day of treatment)	29/04/21
Two weeks after treatment (WAT) timing 1	15/05/21
Four WAT timing 1 & Two WAT timing 2	03/06/21 (T1) & 26/06/21 (T2)
Eight WAT timing 1 & Four WAT timing 2	15/07/21
Four WAT timing 3	23/08/21
Eight WAT timing 3	20/09/21

Table 7 Assessment timings for New Dairy farm year two

Assessment required	Actual timing
Pre-treatment (day of treatment)	05/05/21
Two weeks after treatment (WAT) timing 1	15/05/21
Four WAT timing 1 & Two WAT timing 2	03/06/21 (T1) & 26/06/21 (T2)
Eight WAT timing 1 & Four WAT timing 2	16/07/21
Four WAT timing 3	23/08/21
Eight WAT timing 3	21/09/21

3 RESULTS

3.1 Experimental year one (2019)

3.1.1 Argoed site 2019

The mean plant counts per plot for both sites are summarised in Table 8. There was a good natural population of docks at this site.

Table 8 The mean number of dock plants per plots at each assessment timing at Argoed 2019.

	Mean number of dock plants per plot at each assessment timing					
Treatment	20 May (pre-treatment)	29 May	18 June	4 July	15 July	30 July
Electrical x1	16.67	3.00	6.67	9.00	11.67	10.33
Electrical x2	16.67	2.67	4.00	2.00	5.67	6.33
Electrical x3	12.00	2.33	3.33	1.33	2.67	0.67
Herbicide alone	18.33	3.00	0.33	0.33	0.67	0.67
Electrical fb/ herbicide	16.67	4.00	7.00	1.00	1.00	1.00
Untreated	16.67	26.67	9.33	14.00	14.00	16.00

The results for the final assessment on 30 July 2019 are summarised below as a mean of all replicate plots per treatment, shown as a % reduction from the untreated control (Figure 4).

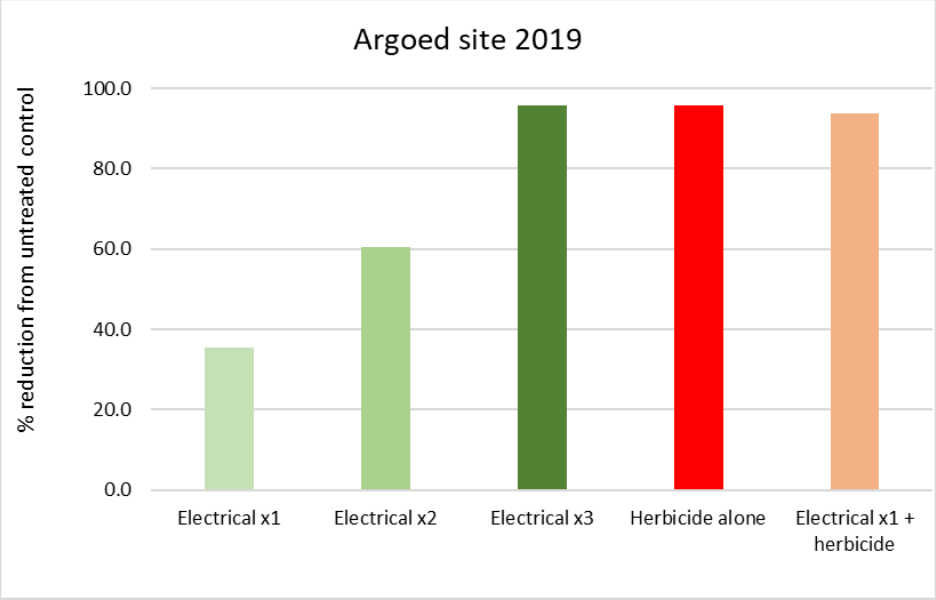

Figure 4 The mean % reduction from the untreated control for all treatments in experimental year one at Argoed site.

The results from trial year one (Figure 4) showed that one electrical treatment was not effective enough (< 40% control) at controlling docks. Two electrical treatments gave a higher level of control (60%); however, three electrical treatments gave the highest level of control (96%), which was equivalent to the herbicide alone. There was no difference in control with the integrated treatment of electrical followed by herbicide, which was equivalent to the herbicide alone, or three electrical treatments.

3.1.2 Llwyncelyn site 2019

There was also a good natural population of docks at this site. Treatment results varied at Llwyncelyn site compared to Argoed in 2019.

Table 9 The mean number of dock plants per plots at each assessment timing at Llwyncelyn 2019.

	Mean number of dock plants per plot at each assessment timing					
Treatment	20 May (pre-treatment)	29 May	18 June	4 July	15 July	30 July
Electrical x1	18.30	3.70	3.30	9.30	8.00	12.00
Electrical x2	20.00	4.30	4.00	4.30	6.00	9.30
Electrical x3	18.30	5.30	4.70	5.30	8.30	7.00
Herbicide alone	23.30	5.00	1.00	0.00	0.00	0.30
Electrical fb/ herbicide	18.30	4.30	4.70	3.00	5.70	6.30
Untreated	14.00	18.30	10.00	21.70	13.00	15.00

By the final assessment timing the same pattern of control from the electrical treatments was seen at this site (Figure 5), with one electrical treatment only achieving 20% control of docks, two electrical treatment 40% and three electrical treatments 53% control compared to the untreated. At this trial site the herbicide treatment alone gave by far the highest level of control at 98%. The electrical treatment followed by a herbicide only achieved 58% control.

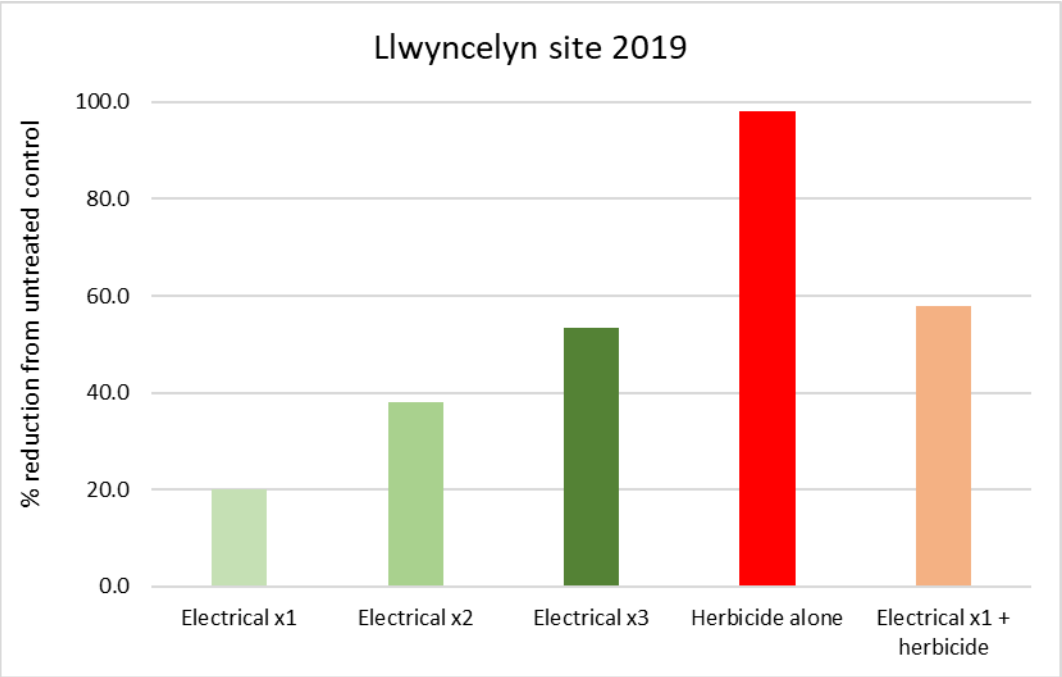

Figure 5 The mean % reduction from the untreated control for all treatments in experimental year one at Llwyncelyn site.

3.2 Experimental year two (2021)

3.2.1 Llwyncelyn site 2021

Data for mean percentage dock ground cover and mean number of dock plants per plot are shown in Table 10. As the timings of treatments vary the treatments that have not had their full treatment at the time of the assessment are highlighted (light grey), but plots were counted as plots are scored 'blind' (with a plot number list only and not treatment number) to ensure there is no bias towards any treatment.

Table 10 The mean percentage ground cover of docks and mean number dock plants per plot at Llwyncelyn at each assessment timing in 2021.

	29 April (Pre-treatment)		15 May (2 WAT T1)		03 June (4 WAT T1 2 WAT T2)		15 July (8 WAT T1 4 WAT T2)		23 August (4 WAT T3)		20 September (8 WAT T3)	
Treatment	*% cover*	No. plants	*% cover*	No. plants	*% cover*	No. plants	*% cover*	No. plants	*% cover*	No. plants	*% cover*	No. plants
Electrical x2	*5.67*	10.00	*2.00*	5.00	*5.00*	5.33	*3.33*	6.33	*4.33*	6.00	*6.00*	6.00
Electrical x3	*9.00*	13.67	*1.67*	5.00	*4.67*	6.67	*4.67*	11.33	*2.17*	4.67	*1.67*	2.00
Electrical fb/ herbicide	*7.67*	13.67	*2.33*	6.33	*4.00*	7.67	*1.33*	2.67	*1.67*	2.67	*2.00*	3.33
Herbicide fb/ electrical	*7.33*	11.33	*7.00*	13.33	*8.67*	12.00	*0.00*	0.00	*0.50*	1.00	*1.00*	0.67
Herbicide alone	*7.00*	13.33	*8.00*	14.33	*8.67*	14.00	*0.33*	0.67	*0.33*	0.67	*0.67*	1.67
Untreated	*8.67*	13.33	*8.67*	15.33	*10.00*	15.33	*6.67*	15.33	*9.67*	14.00	*10.67*	14.67

(WAT= Weeks after treatment/ fb= followed by)

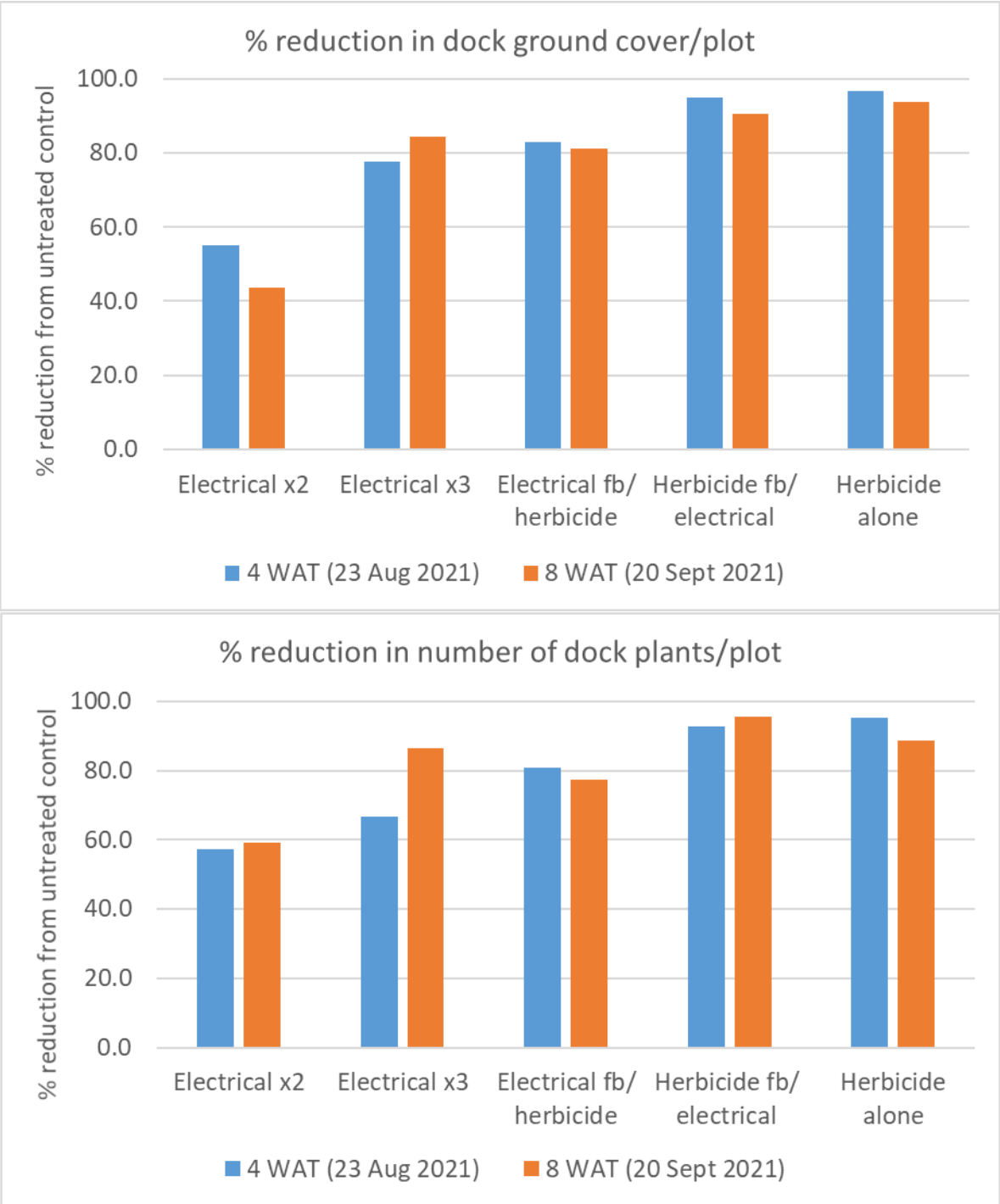

Figure 6 The mean percentage reduction from the untreated control for percentage dock ground cover and number of dock plants per plot at Llwyncelyn for the final two assessment timings in 2021, at four and eight weeks after full treatments (WAT).

General observations of the trial reported on 15 May 2021 that some docks in plots treated with a single electrical treatment were re-growing from the crown. There were also one or two small docks newly emerging, that were therefore not treated at first treatment timing. An overall observation on this date was that the untreated docks were growing slowly after being grazed. On 26 June 2021 it was reported that the herbicide treatments were visibly very effective, and a few dock plants had been grazed. By August 2021 there was a good general sward after the field had been topped.

Results show that using a visual assessment system of scoring percentage dock ground cover compared to counting the total number of dock plants per plot achieved equivalent results. There were a few small differences by the 8WAT assessment, where counting the number of plants per plot indicated a marginally higher number of docks present.

At assessment timing of 8WAT, for percentage dock cover, the electrical treatment on three timings gave 84% control compared to two timings of 44% control (Figure 6), so was much more effective at controlling docks. In this trial the herbicide treatment alone was the most effective treatment (94% control), however this was closely followed by an integrated treatment of a herbicide followed by electrical treatment (91%). One electrical treatment followed by the herbicide treatment achieved 81% control, so was comparable to three electrical treatments alone (84%).

3.2.2 New Dairy farm

Data for mean percentage dock ground cover per plot are shown in Table 11 . As the timings of treatments vary the treatments that have not been applied at the time of the assessment are highlighted (light grey), but plots were counted as plots were scored 'blind' (with a plot number list only and not treatment number) to ensure there is no bias towards any treatment.

Table 11 The mean percentage ground cover of docks per plot at New Dairy farm at each assessment timing in 2021.

	Mean % ground cover docks						
Treatment	05 May (Pre-treatment)	15 May	04 June	26 June	16 July	23 August	21 September
Electrical x2	13.33	4.67	6.00	9.67	26.67	56.67	53.33
Electrical x3	7.33	5.33	5.33	8.67	15.00	24.00	28.33
Electrical fb/ herbicide	6.00	3.00	4.00	2.33	12.00	14.33	15.00
Herbicide fb/ electrical	8.67	24.33	21.67	1.53	6.67	15.00	18.33
Herbicide alone	13.67	25.00	25.00	2.83	10.33	22.67	33.33
Untreated	9.33	19.00	21.67	7.33	25.00	61.67	60.00

**fb = followed by*

General observations of the trial reported on 15 May 2021 that some docks in plots treated once with an electrical treatment were re-growing from the crown and that there was lots of standing water in the field with very high-water levels in the surrounding ditches. By 04 June 2021 the untreated dock plants had stem elongation and flowering heads were starting to form. By 26 June 2021 it was noted that there were areas within the trial that had a crusted slurry layer and cut grass, so it was more difficult to assess the percentage dock cover.

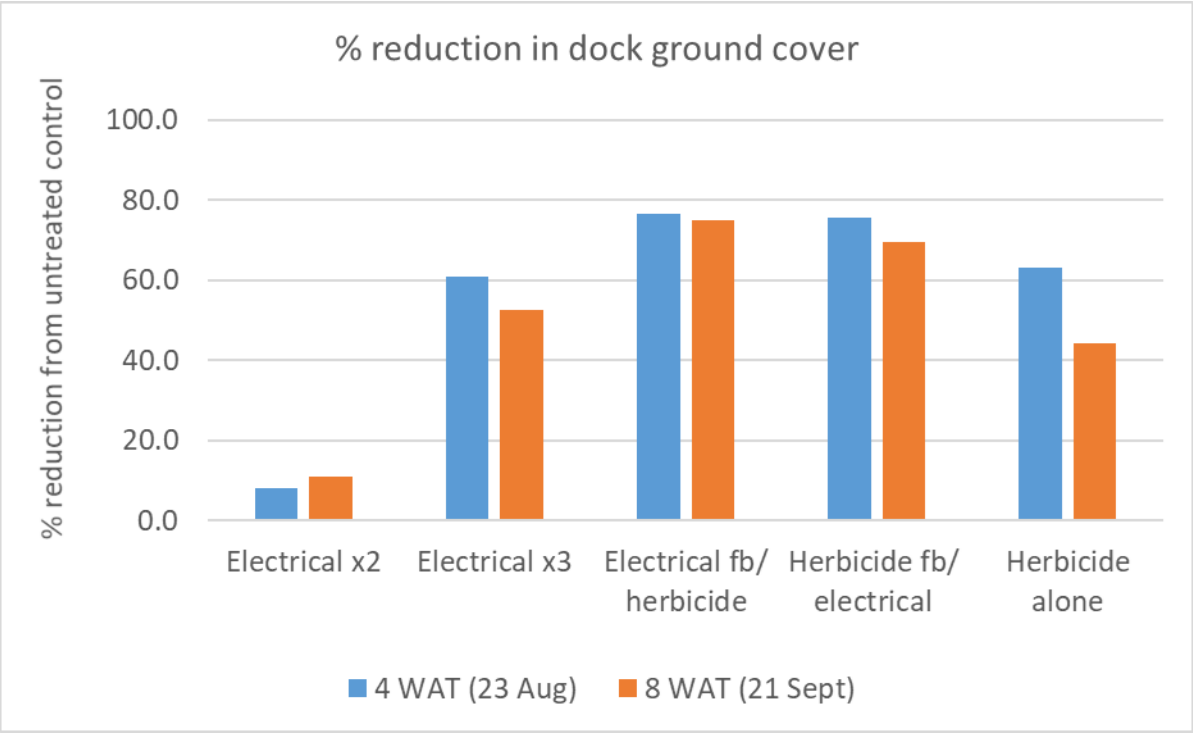

Figure 7 The mean % reduction from the untreated control for % dock ground cover at New Dairy farm for the final two assessment timings in 2021, at four and eight weeks after full treatments (WAT).

Results show that the efficacy of control at New Dairy site was generally lower than Llwyncelyn, with the highest treatment below 80% control of docks, compared to the untreated control. Two timings of electrical treatment were not adequate to control docks at this site (less than 11% control). However, three electrical treatments showed a 61% control of docks four weeks after full treatment, which was equivalent to the herbicide alone (63%) at this site. The integrated treatments including one herbicide application either before or after an electrical treatment showed the same level of control at 76% compared to the untreated control.

3.3 Standard soil analysis for each trial site

Soil samples were taken for both sites in each trial year and sent to NRM laboratories for a standard soil analysis assessment. Results are shown in Table 12 and Table 13.

Table 12 The soil analysis for both field sites in 2019

		Index			***mg/l (available)***		
Site	**pH**	**P**	**K**	**Mg**	***P***	***K***	***Mg***
Argoed	6.3	3	2	3	*31.2*	*139*	*135*
Llwyncelyn	6.7	4	5	4	*50.6*	*655*	*222*

Table 13 The soil analysis for both field sites in 2021

		Index			*mg/l (available)*		
Site	**pH**	**P**	**K**	**Mg**	***P***	***K***	***Mg***
Llwyncelyn	6.1	5	5	5	*74.6*	*764*	*252*
New Dairy	6.8	5	5	5	*71.6*	*762*	*329*

4 DISCUSSION

Trial results over two seasons have shown that electrically treating dock plants at three treatment timings is very effective and can be equivalent to a herbicide application alone. Electrical control is extremely promising as an additional tool for dock management in grassland, that would benefit organic farmers or those seeking to reduce herbicide inputs.

There was a difference in the electrical treatment results between the two sites in 2019, which was likely due to the weed growth stage at treatment. Although the sites were located geographically very close there was a big difference in the dock growth stage at the time of treatment due to the different grazing regimes. This was a limitation as we were in a trial situation and had to move the kit to the site when it was available. If kit was locally available or owned by a farmer then there would be a greater degree of flexibility for application timing.

Further improvements in results could potentially be achieved with bespoke mobile equipment designed specifically for treating large dock plants and different treatment regimes.

Herbicides require an actively growing plant that is not too small or large, so getting the application timing correct for optimal uptake and efficacy is very important. For New Dairy Farm in 2021 the dock growth stage was too large for the optimum timing of the herbicide, as is reflected in the slightly lower control level.

The herbicide used in these trials was not clover safe, so it killed any clover in the grass sward. This can be viewed as a negative effect to the farmer as they require the clover for fertility and ley quality. Selectively controlling docks using electrical control would retain the clover in the sward (if it was not directly touched by the machine). However, the use of a combination of electrical treatment and herbicides could also be a favourable option for the future. If the weed growth stage is getting too large and a farmer is unable to get the spray applied due to adverse weather conditions or a lack of a contractor then the weed could be checked by the electrical treatment and potentially then sprayed at the optimal timing. We tried to investigate the efficacy of this approach by adding a treatment including the combined actions. The results from New Dairy farm in 2021 reflect the benefit of this integrated approach, where an electrical treatment was applied in May that would have controlled or significantly knocked back the docks and then a follow-up herbicide treatment a month later was highly effective as the growth stage was more favourable.

These trials were deliberately placed on fields that were being actively grazed and cut during the season and this comes with its challenges from a trial perspective. The grassland management on all sites was slightly different and the trial treatments were not always slotted into the same phase of grassland management on each site. When interpreting the results this must be considered as we were only controlling the trial treatments and did not factor in other grassland management or inputs such as fertilisers. Future trials could include more controlled conditions to allow direct comparison.

All contractors and farmers have worked well together to implement the trial methodology for this project. An initial technical problem with the Rootwave Pro and then a Health and Safety concern caused by snow laying on sites postponed initial planned treatment on 04 April 2019. This resulted in the first treatments being delayed several weeks to May 2019, but once trials began, they were maintained on target. The project steering group met at the trial sites on 25 September 2019 to discuss the results from year one and planning for year two. This led to very useful input into the design of trial year two including planning to start earlier, leaving a bigger gap between treatments and to monitor the sites for longer. However, COVID-19 restrictions resulted in trial year two being delayed for a whole season as we were unable to travel or access farms. It also prevented a follow-up assessment from the field plots in trial year one to assess any longer-term control from each treatment.

Feedback from the host-farmers proved their interest in the technology and that they saw great scope for the future if the kit could be tractor-mounted. They were particularly interested in the fact they could potentially retain more clover in a sward by using this type of technology to patch treat the weeds in a field compared to an overall herbicide spray that may result in loss of clover.

The limitations with the Rootwave Pro kit in this grassland field situation is lack of mobility. Farmers require a tractor-mounted system that can travel at a reasonable speed before they will use this system on farm. However, this system proved the concept of effective weed control and it is well-suited to other environments such as nature reserves or amenity areas. The manufacturers can be contacted directly to provide information regarding the cost of the hand-held system and any predicted cost of a tractor-mounted system for the future. There have been no economic evaluations within this project to compare the time or fuel required to control docks by herbicide compared to electrical weeding in grassland. This should be considered in future work when a tractor-mounted system is available for testing, however it would not have been practical or relevant to base any economic assessment on the protype hand-held system used in plots rather than field-scale. There is also potential with advances in technology development for an electrical system to be integrated into a vision guided system in the future.

5 CONCLUSIONS

Overall results have concluded that electrically treating dock plants on three treatment timings was very effective and can be equivalent to a herbicide application alone. Electrical control is extremely promising as an additional tool for dock management in grassland, that would benefit organic farmers or those requiring lower herbicide inputs. It would also retain clover in the sward if targeted treatments were applied. The tractor-mounted system is urgently required for uptake of this technology into the grassland market for it to be a commercially viable option.

Widening the scope of the experiments to longer-term treatments and assessments (3-4 years), with the inclusions of more herbicide options (e.g., a clover-safe herbicide) for increased comparisons would be beneficial to the farmer.

In conclusion, electrical control of docks and potentially other perennial weeds in grassland could be a very effective integrated weed management method for future weed control.

6 APPENDIX

6.1 General trial photos 2018-19

Electrical Dock Control -General photos to demonstrate the trials	
Trial site May 2018- Pre-Project planning stage	
Dock electrocution	
Rootwave Pro kit – including the generator	

Electrical treatment lance (T-shaped)	
Electrode touching dock target	
Dock electrocution	
5-10 second contact time with dock	

End of electrocution	
Dock post electrocution- 5 minutes	
Dock growth stage assessment	

6.2 Photos – Llwyncelyn 15 July 2021


Trt 4 = Herbicide + Electric x 1


Trt 5 = Herbicide


Trt 6 = Untreated

6.3 Photos- New Dairy Farm - June 2021


Trt 4 = Herbicide + Electric x 1


Trt 5 = Herbicide


Trt 6 = Untreated