EIPWALES
Cydweithio er ffyniant gwledig
Collaborating for rural success

menter a busnes

Foliar Feed for Grassland

The issue

Most nitrogen (N) fertilisers are applied in solid (prilled) form. The nutrients are washed into the topsoil by rain and subsequently taken up by the roots of the plants. A host of factors such as soil compaction, drainage, bio-activity, soil temperature, dry or wet weather can affect the nutrient release and uptake by the grass with this method. There is another, more direct, method of getting nitrogen into the grass which is through the pores in the leaves.

The project

This EIP Wales project looked at the extent to which using a foliar feed, based on urea and humic acid, can reduce the application of 'conventional' nitrogen (N) fertiliser to the soil while maintaining dry matter (DM) yield. Four farmers in Pembrokeshire and Ceredigion participated in the trial from 2019 - 2021.

They each split one large field into three sections of equal size with the following treatments

- Standard prilled nitrogen (N) application (125 kg/Ha of product)
- Foliar feed based on urea and humic acid, applied at three-week intervals during the grazing season (20 kg/Ha of product)
- Control (no nitrogen)
- In the second year of the project, a silage plot was added on one of the sites
- In the third year, in light of previous years data, we decided to look at the effect of increasing N concentration in the foliar feed mix on Nitrogen use Efficiency (NUE).
- The dry matter yield and the N content of fresh grass was measured using a plate meter and nitrate meter during the year (January – December).

Results

Lower rates of foliar fed N

Yield

Absolute yields varied significantly across the sites, and this is a reflection of the differences in growing conditions and elevation; the elevation varied from site 2 which is south facing at about 30 metres above sea level, to site 3 which is north facing and 300 m. However, broadly speaking, the relative differences were similar across all sites in both years (2019 and 2020): Yield was highest in conventional plots, lowest in the control plots and approximately midway between the two on the foliar feed plots. Yields were between 1 and 3 t/Ha higher in

Llywodraeth Cymru
Welsh Government

conventional plots compared to foliar feed plots (Figures 1 and 2). This was not unexpected as the conventional plots received significantly more N (Tables 1 and 2). However, there were exceptions:

- In 2019, the foliar feed plots grew 0.5 – 1.0 tons dry matter (t DM/ha) more than the conventional plots up to the end of April, indicating faster early growth. This could be because of more rapid uptake of N through the leaves compared to absorption through the roots at lower soil temperatures.
- In 2020, the foliar feed plots had higher yields at site 2 and 3 (2.5 and 0.8 t DM/ha more respectively). This is possibly due to soil moisture conditions; the spring of 2020 was exceptionally dry, and therefore the uptake from the conventional fertiliser through the roots may have been greatly reduced. The application of foliar feed bypasses the need for nutrients to be taken up through the roots, and therefore for high soil moisture content.

The results suggest that foliar feeding may lead to increased yield in cold and or dry conditions, compared to conventional, due to improved N uptake. Further research is needed to confirm this.

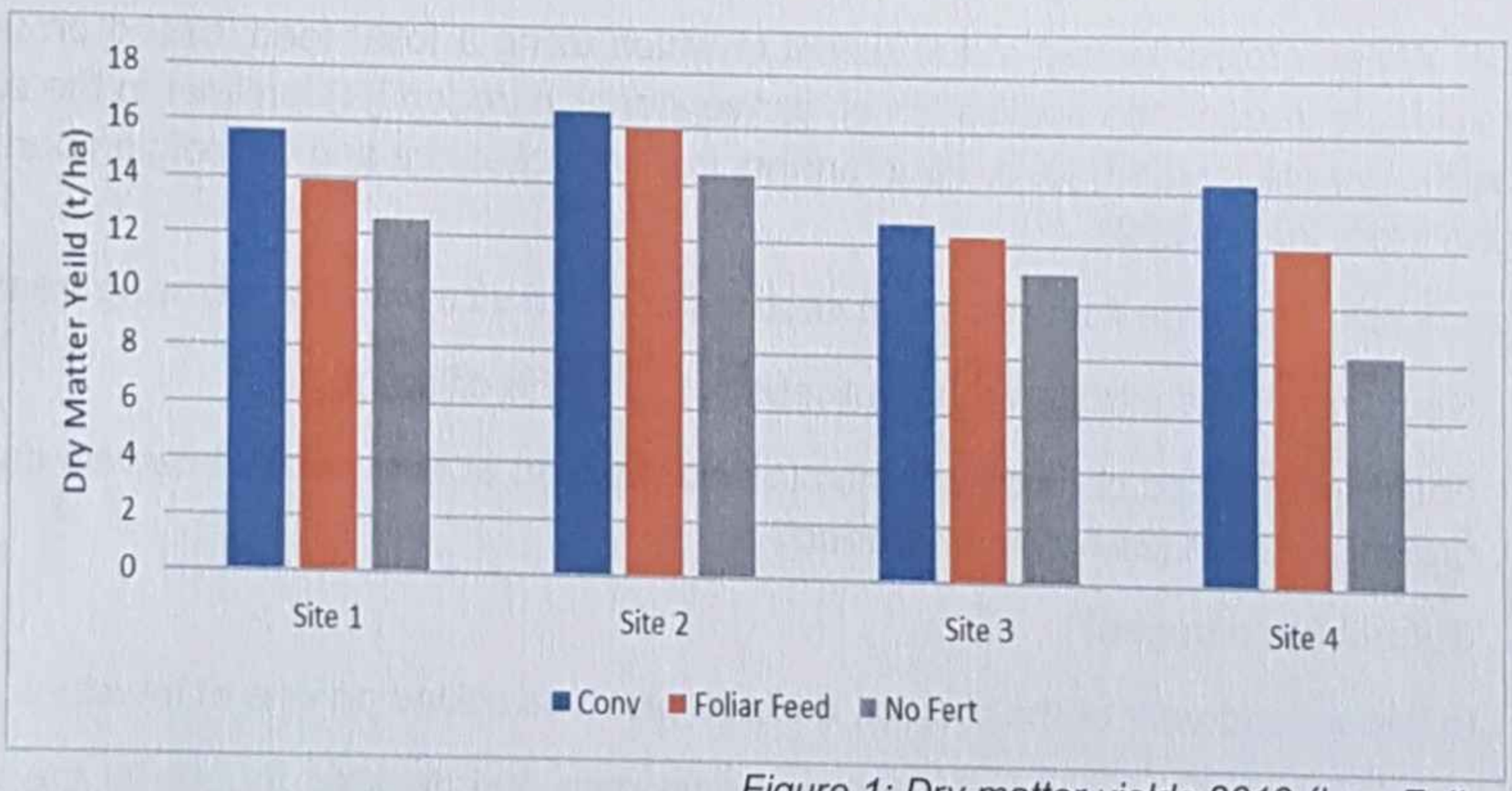

Figure 1: Dry matter yields 2019 (Low Foliar Fed N)

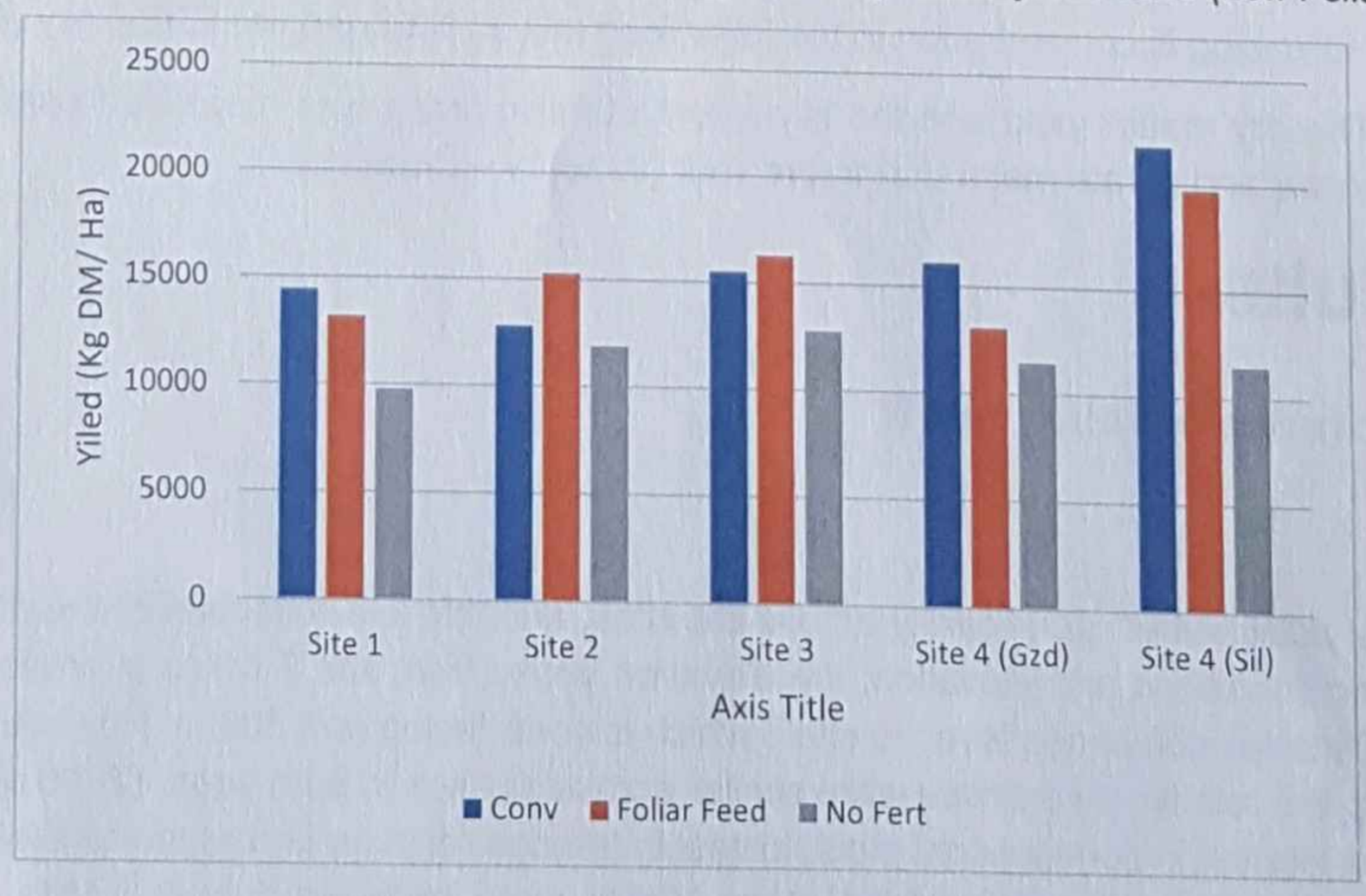

Figure 2: Dry matter yields 2020 (Low Foliar Feed N)

Llywodraeth Cymru
Welsh Government

Nitrogen use efficiency

A key finding of the project is that, at lower N concentrations, the foliar feed substantially increases NUE compared to conventional fertiliser. NUE is defined as the increase in DM yield per additional Kg of N applied. On average, NUE was between 2 and 4 times (200% – 400%) higher on the foliar fed plots compared to the conventional plots (Tables 1 and 2). In one instance it was 16.5 (1600%) times higher, although this is likely to be an anomaly in the data.

This increase in NUE is likely to be down to a number of factors:

- The humic acid within foliar feed actively carries the N into the plant. This process is more efficient than absorption through the roots.
- Humic acid is also a source of carbon which means the energy required for absorption is more readily available and does not need to draw on the soil's energy reserves.
- Where foliar feed enters the soil, humic acid is known to aid soil activity and make mineral and trace elements more readily available to plants.

Site	Conv			Foliar Feed			Foliar feed NUE compared to conv (%)
	Total N applied (Kg/ Ha)	Additional Yield (Kg/ Ha)	NUE (additional Kg DM/ Kg N	Total N applied (Kg/ Ha)	Additional Yield (Kg/ Ha)	NUE (additional Kg DM/ Kg N	
Site 1	250	3100	12.4	46	1300	28.3	228
Site 2	250	2200	8.8	64	1600	25.0	284
Site 3	212	1700	8.0	72	1300	18.1	225
Site 4	268	6000	22.4	72	3800	52.8	236

Table 1: Nitrogen Use Efficiency at lower concentrations of N in foliar feed - 2019

Site	Conv			Foliar Feed			Foliar feed NUE compared to conv (%)
	Total N applied (Kg/ Ha)	Additional Yield (Kg/ Ha)	NUE (additional Kg DM/ Kg N)	Total N applied (Kg/ Ha)	Additional Yield (Kg/ Ha)	NUE (additional Kg DM/ Kg N	
Site 1	275	4600	16.7	75	3400	45.3	271
Site 2	205	900	4.4	47	3400	72.3	1648
Site 3	275	2700	9.8	93	3500	37.6	383
Site 4 (Gzd)	240	4600	19.2	65	1600	24.6	128
Site 5 (Sil)	460	10300	22.4	182	8300	45.6	204

Table 2: Nitrogen Use Efficiency at lower concentrations of N in foliar feed - 2020

Llywodraeth Cymru
Welsh Government

High rates of foliar fed N

In the final year of the project (2021), we looked at whether, given the greater NUE of foliar feed, increasing the N concentration of the feed would proportionately increase the yield. In this third year, the N applied by foliar feeding was increased from an average of approximately 70 Kg N/Ha to 100 Kg N/Ha

Yield

As Figure 3 shows, the increase in N concentration in the foliar feed resulted in broadly similar yields on conventional and foliar fed plots, in both grazed and silage systems. There was one exception (Site 1). This is likely to be due to field conditions in the foliar fed plot compared to conventional, rather than the applications of N. Possibilities include: low levels of magnesium on this site, which may lock up nutrients and reduce the benefit of applying N; and a lighter soil on the foliar fed plots which may have had in impact especially during the drought in late spring of 2021.

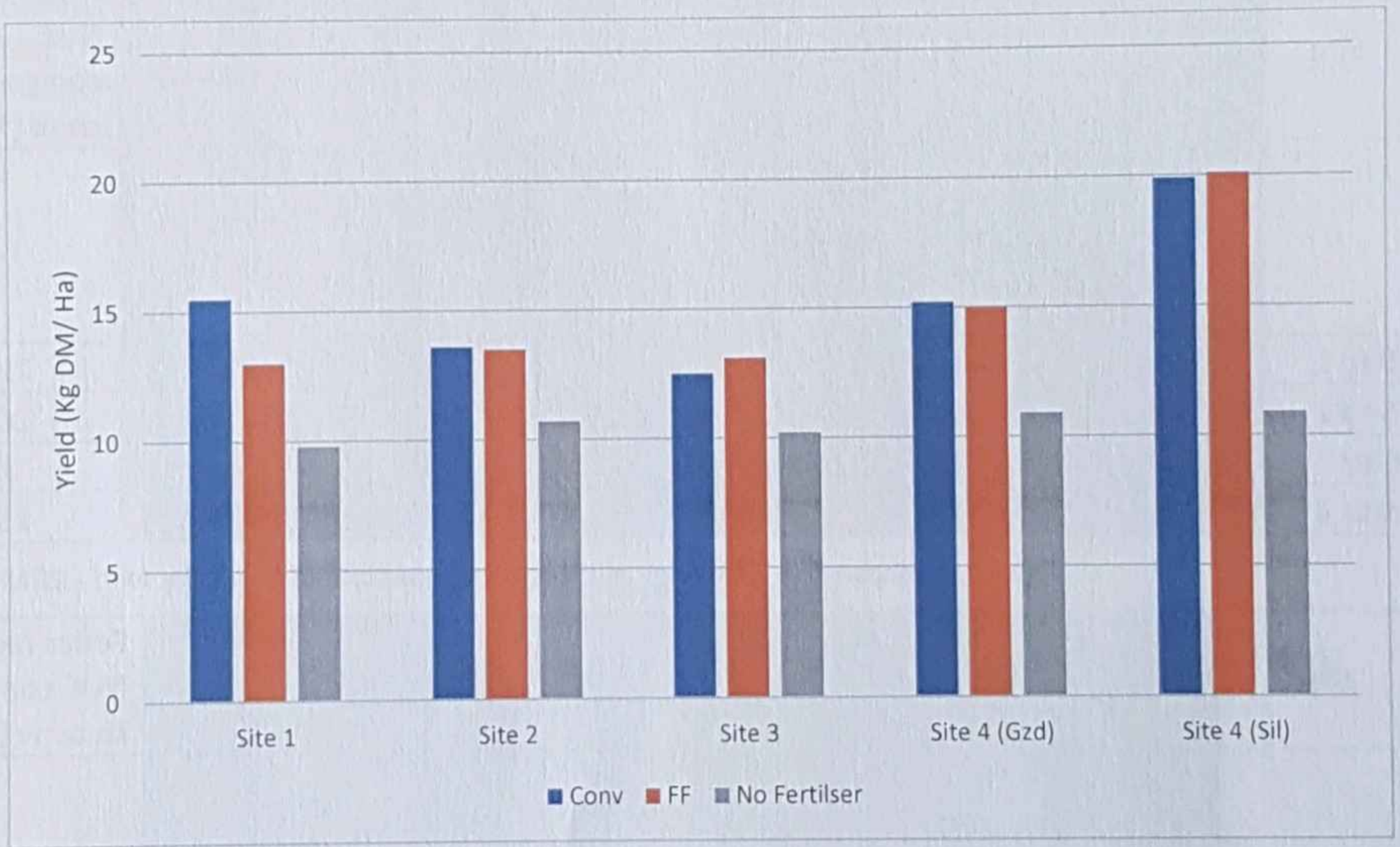

Figure 3: Dry matter yields 2021 (High N Foliar Feed)

Nitrogen use efficiency

On all sites with exception of site 1, NUE continued to be significantly higher in foliar fed plots, achieving similar DM yields to conventional plots by applying only 40 – 50% of the nitrogen, depending on the specific site. The variation between sites and years makes it difficult to draw firm conclusions about the relationship between the concentration of N in the foliar feed and NUE.

Llywodraeth Cymru
Welsh Government

Site	Conv			Foliar Feed			Foliar feed NUE compared to conv (%)
	Total N applied (Kg/ Ha)	Additional Yield (Kg/ Ha)	NUE (additional Kg DM/ Kg N	Total N applied (Kg/ Ha)	Additional Yield (Kg/ Ha)	NUE (additional Kg DM/ Kg N	
Site 1	275	5700	20.7	110	3200	29.1	140
Site 2	245	2900	11.8	92	2800	30.4	257
Site 3	275	2300	8.4	110	2900	26.4	315
Site 4 (Gzd)	270	4300	15.9	92	4100	44.6	280
Site 4 (Sil)	425	9000	21.2	224	9200	41.1	194

**The project ended in September 2021. In order to obtain a measure of the NUE, grass growth from October – December 2021 was estimated from figures from the two previous years of the project.*

Table 3: Nitrogen Use Efficiency at higher concentrations of N in foliar feed - 2021

Costs and benefits

Table 4 compares the cost of N per litre of additional milk (i.e. over and above that produced on the 'no fertiliser plots') for conventional and foliar fed systems. Energy requirements were used to estimate the volume of milk produced in each system, assuming that 5.5MJ of energy are needed to produce a litre of milk and that forage contained approximately 11.5 MJ/ Kg DM (based on forage analysis of the plots).

The cost of the foliar feed ingredients was about 25% higher compared to conventional fertiliser. This is partly because foliar feed requires unprotected urea to be used which is more expensive (£360 £/t) and partly because of the cost of humic acid (approximately £2.25/ha) The application costs for foliar feed are also much higher than for conventional fertiliser (about £15/ha for applying foliar feed compared to about £7.5/ha for applying granular fertiliser)

However, these additional costs were more than compensated for by increased NUE in the foliar plots. On all sites, in all years the cost of nitrogen per litre of milk was lower in foliar fed compared to conventional plots. The difference varied from site to site, but in most cases foliar feeding was between 40 - 50% more cost effective.

Summary

- At higher rates of N, foliar feeding can support comparable yields to conventional application systems.
- Nitrogen Use Efficiency is significantly greater (between two and three times higher in most cases) by foliar feeding.
- Foliar feeding appear to give higher yields in adverse conditions, for example cool and/or dry conditions. This likely to be because absorption through the leaves is less affected by adverse soil conditions compare to uptake through the roots.
- Foliar feeding can deliver significant benefits in terms of reducing the N costs per litre of milk produced.

Llywodraeth Cymru
Welsh Government

2019 (Low N)	System	kg N applied	Ingredients (£/Kg N)	Application	Total Cost of N	Additional* DM Yield Kg/ Ha	Additional* ME (MJ/Ha)	Additional* Milk p (l/ Ha)	Cost N (ppl additional* milk)
Site 1	Conventional	250	£ 250.00	£ 7.50	£ 257.50	3100	35650	5185	**4.97**
	FF	46	£ 56.58	£ 15.00	£ 71.58	1300	14950	2175	**3.29**
Site 2	Conventional	250	£ 250.00	£ 7.50	£ 257.50	2200	25300	3680	**7.00**
	FF	64	£ 78.72	£ 15.00	£ 93.72	1600	18400	2676	**3.50**
Site 3	Conventional	212	£ 212.00	£ 7.50	£ 219.50	1700	19550	2844	**7.72**
	FF	72	£ 88.56	£ 15.00	£ 103.56	1300	14950	2175	**4.76**
Site 4 (Gzd)	Conventional	268	£ 268.00	£ 7.50	£ 275.50	6000	69000	10036	**2.75**
	FF	72	£ 88.56	£ 15.00	£ 103.56	3800	43700	6356	**1.63**

2020 (Low N)	System	kg N applied	Ingredients (£/Kg N)	Application	Total Cost of N	Additional* DM Yield Kg/ Ha	Additional* ME (MJ/Ha)	Additional* Milk produced (l/ Ha)	Cost N (ppl additional* milk)
Site 1	Conventional	275	£ 275.00	£ 7.50	£ 282.50	4500	51750	7527	**3.75**
	FF	93	£ 114.39	£ 15.00	£ 129.39	3400	39100	5687	**2.28**
Site 2	Conventional	205	£ 205.00	£ 7.50	£ 212.50	900	10350	1505	**14.12**
	FF	47	£ 1.23	£ 15.00	£ 16.23	3400	39100	5687	**0.29**
Site 3	Conventional	275	£ 275.00	£ 7.50	£ 282.50	2700	31050	4516	**6.26**
	FF	75	£ 92.25	£ 15.00	£ 107.25	3500	40250	5855	**1.83**
Site 4 (Gzd)	Conventional	240	£ 240.00	£ 7.50	£ 247.50	4600	52900	7695	**3.22**
	FF	65	£ 79.95	£ 15.00	£ 94.95	1600	18400	2676	**3.55**
Site 4 (Sil)	Conventional	460	£ 460.00	£ 7.50	£ 467.50	10300	118450	16152	**2.89**
	FF	182	£ 223.86	£ 15.00	£ 238.86	8300	95450	17355	**1.38**

**'Additional' refers to product (forage, energy & milk) 'over and above the 'no fertiliser' plots*

Llywodraeth Cymru
Welsh Government

2021 (High N)	System	kg N applied	Ingredients (£/Kg N)	Application	Total Cost of N	Additonal DM Yield Kg/ Ha	Additonal ME (MJ/Ha)	Additonal Milk produced (l/ Ha)	Cost N (ppl additional milk)
Site 1	Conventional	275	£ 275.00	£ 7.50	£ 282.50	5700	65550	9535	**2.96**
	FF	110	£ 135.30	£ 15.00	£ 150.30	3200	36800	5353	**2.81**
Site 2	Conventional	245	£ 245.00	£ 7.50	£ 252.50	2900	33350	4851	**5.21**
	FF	92	£ 113.16	£ 15.00	£ 128.16	2800	32200	4684	**2.74**
Site 3	Conventional	275	£ 275.00	£ 7.50	£ 282.50	2300	26450	3847	**7.34**
	FF	110	£ 135.30	£ 15.00	£ 150.30	2900	33350	4851	**3.10**
Site 4 (Gzd)	Conventional	270	£ 270.00	£ 7.50	£ 277.50	4300	49450	7193	**3.86**
	FF	92	£ 113.16	£ 15.00	£ 128.16	4100	47150	6858	**1.87**
Site 4 (Sil)	Conventional	425	£ 425.00	£ 7.50	£ 432.50	9000	103500	14114	**3.06**
	FF	224	£ 275.52	£ 15.00	£ 290.52	9200	105800	14427	**2.01**

Assumptions	***Conventional***	***FF***	***Notes***
Cost ingredients (£/Kg N)	*£1.00*	*£1.23*	*FF Calculated from project costs*
Cost of application (£/ Ha)	*£7.50*	*£15.00*	*FF assumed same as spraying*
ME requirement/ l milk (MJ)	*5.50*	*5.50*	*Std Industry*
Energy in forage (MJ / Kg DM)	*11.50*	*11.50*	*From forage analysis*
Energy Utilisation (grazing)	*80%*	*80%*	
Energy Utilisation (silage)	*75%*	*75%*	

Table 4: N costs per litre of milk

Nigel Howells **Email:** nigelhowells1@btinternet.com **Phone:** 07973 545 056

Llywodraeth Cymru
Welsh Government