Portsmouth Water Foliar Nitrogen Trial 2020-23

MAY 25

S. Woodley Crop Services
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Introduction:

Granular fertilisers, such as ammonium nitrate (AN), are the most common nitrogen fertilisers used on arable farms. Recovery of applied nitrogen has been estimated within the range of 45-85% and UK fertiliser recommendations (RB209) suggest the average recovery rate is approximately 60% (AHDB, 2022). Excess nitrogen not utilized by the crop has potential to be lost to the wider environment through leaching, potentially polluting groundwater sources. Stephen Woodley and Portsmouth Water identified that alternative fertiliser formulations may improve the efficiency of nitrogen use by arable crops and provide an opportunity to reduce total nitrogen input.

The trial:

In 2020, Portsmouth Water and S. Woodley Crop Services formed a trial with R.S Payton to compare granular nitrogen fertiliser with an alternative foliar fertiliser formulation. AGRO-VITAL UK Ltd. market a urea-based liquid, foliar applied nitrogen fertiliser (Efficie-N^{28}-t) that claims to provide improved nitrogen use efficiency. Efficie-N^{28}-t was used to explore the use of foliar nitrogen at lower total nitrogen rates, to understand whether leaching could be reduced whilst maintaining crop performance and economic output.

1. Control (farmers standard practice, mixture of liquid and granular)
2. Three applications of E28 (T1.5, T2 & T3 fungicide timings)
3. One application of E28 & T3
4. Pure Granular applications

Table 1: Nutrient applications on the trial plots:

Control: Efficient N28 @ T2: Normal application of liquid fertiliser followed by a second application of granular AN. Efficient N 28 @ T2 followed by a granular AN application as a finisher in June. Total N: 207kg N/ha	Plot 1: Efficient N28 x 3: Normal application of liquid fertiliser followed by a second application of granular AN. Followed by 3 applications of Efficient N 28 @ T1.5, T2 & T3 Total N: 161kg N/ha	Plot 2: Efficient N28 Finisher: Normal application of liquid fertiliser followed by a second and third application of granular AN. Finished with Efficient N 28 @ T3 Total N: 192kg N/ha	Plot 3: AN Granular Normal application of liquid fertiliser followed by a second and third application of granular AN. Total N: 224kg N/ha
50 Kg N/ha + 50 Kg SO3/ha 263lt /ha of N19 + 19SO3 liquid fertiliser early/mid-march.	50 Kg N/ha + 50 Kg SO3/ha 263lt /ha of N19 + 19SO3 liquid fertiliser early/mid-march.	50 Kg N/ha + 50 Kg SO3/ha 263lt /ha of N19 + 19SO3 liquid fertiliser early/mid-march.	50 Kg N/ha + 50 Kg SO3/ha 263lt /ha of N19 + 19SO3 liquid fertiliser early/mid-march.
90 Kg N/ha 269 kg /ha of Ammonium Nitrate granular fertiliser mid-April.	90 Kg N/ha 269 kg /ha of Ammonium Nitrate granular fertiliser mid-April.	90 Kg N/ha 269 kg /ha of Ammonium Nitrate granular fertiliser mid-April.	90 Kg N/ha 269 kg /ha of Ammonium Nitrate granular fertiliser mid-April.
	7Kg N/ha 20l of Efficient N 28 @T1.5		
7Kg N/ha 20l of Efficient N 28 @T2	7Kg N/ha 20l of Efficient N 28 @T2	45 Kg N/ha 145kg / ha of Ammonium Nitrate granular fertiliser late May.	84 Kg N/ha 250kg / ha of Ammonium Nitrate granular fertiliser late May.
60 Kg N/ha 179kg / ha of Ammonium Nitrate granular fertiliser late May.	7Kg N/ha 20l of Efficient N 28 @T3	7 Kg N/ha 20l of Efficient N 28 @T3	

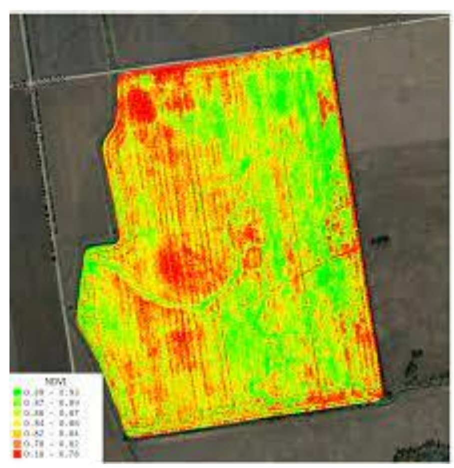
Methodology:

Soil Sampling:
Soil mineral nitrogen sampling was carried out in February prior to any organic manure applications to set a baseline of nitrate levels within the soil. P, K, Mg and OM samples were also taken to understand the variability across the field. SMN samples where repeated after harvest and again in late February each year.

Visual differences:
Site visits were made throughout the growing season to determine any differences in wheat growth.

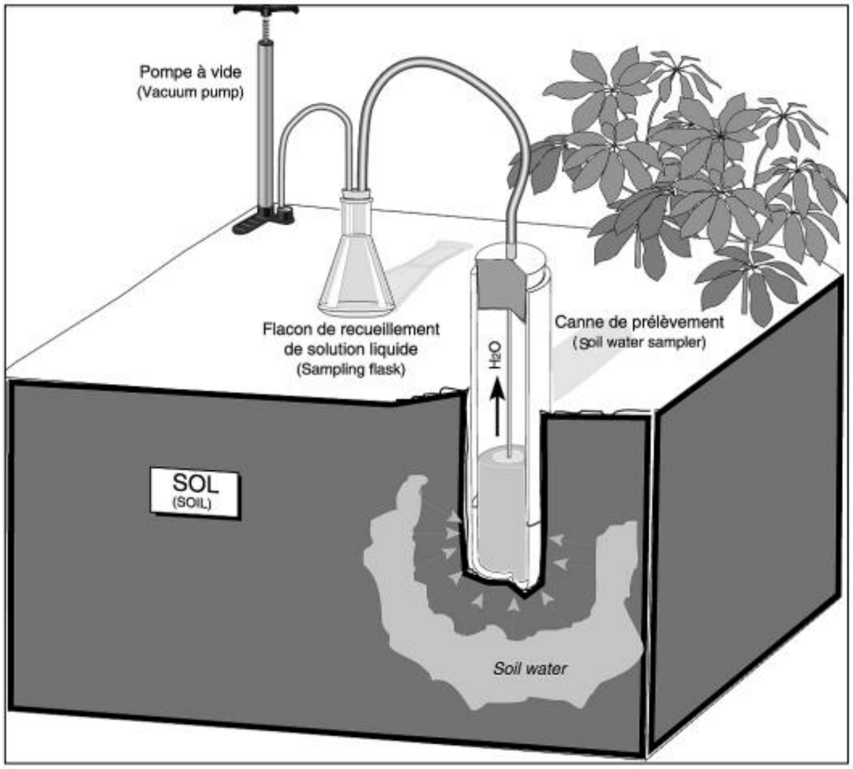
Tissue Samples:
Tissue samples were taken each month March-June to measure any potential nutrition deficiencies in the plants.

Satellite Biomass Imagery:
Weekly satellite images to monitor any potential changes in GAI across the trial plots.



Yield and grain analysis:

Yield data gathered at the point of harvest and grain analyzed for protein content.



Porous Pots:

Twelve porous pots were installed in each treatment, giving a total of 48 porous pots across the trial. Porous pots were sampled once every two weeks from the beginning of October through to the end of February. The water samples gathered from the porous pots were analyzed as fresh samples for nitrate levels (mg/l) which provided an excellent indication of the amount of nitrate leaching through the soil profile.

Table 2: SMN (Soil Mineral Nitrogen) Results 2020-2021:

Field Reference	Feb 2020 SMN (kgN/ha)	September 2020 SMN (kgN/ha)	January 2021 SMN kgN/ha)
Control	18	29.3	24.8
Plot 1	16.2	13.8	30.6
Plot 2	16.4	20.3	25.6
Plot 3	14	13.9	23
Average	16.15	19.3	26

Table 3: SMN (Soil Mineral Nitrogen) Results 2021-2022:

Field Reference	Feb 2021 SMN (kgN/ha)	September 2021 SMN (kgN/ha)	January 2022 SMN kgN/ha)
Control	26.7	28.8	43
Plot 1	19	26	68
Plot 2	19.5	30.9	55
Plot 3	19.5	46.1	66
Average	21.2	33	58

Table 4: SMN (Soil Mineral Nitrogen) Results 2022-2023:

Field Reference	Feb 2022 SMN (kgN/ha)	September 2022 SMN (kgN/ha)	January 2023 SMN kgN/ha)
Control	34	51	33
Plot 1	39	48	29
Plot 2	29	74	27
Plot 3	31	59	27
Average	33	58	29

Table 5: Tissue Sample Results 2020:

SAMPLE	Average N Content in plant N:S Ratio % **31-03-2020**	Average N Content in plant N:S Ratio % **30-04-2020**	Average N Content in plant N:S Ratio % **05-06-2020**	Combined Average N:S Ratio %
Control	3.92	4.2	1.92	3.35
Plot 1	4.14	3.68	1.45	3.09
Plot 2	3.93	4.12	1.68	3.24
Plot 3	4.13	4.4	1.81	3.45

Table 6: Tissue Sample Results 2021:

SAMPLE	Average N Content in plant N:S Ratio % **06-04-2021**	Average N Content in plant N:S Ratio % **11-05-2021**	Average N Content in plant N:S Ratio % **03-06-2021**	Combined Average N:S Ratio %
Control	4.14	2.43	2.22	2.93
Plot 1	4.08	2.19	1.87	2.71
Plot 2	4.03	2.28	2.19	2.83
Plot 3	3.76	2.29	2.58	2.88

Table 7: Tissue Sample Results 2022:

SAMPLE	Average N Content in plant N:S Ratio % **06-04-2022**	Average N Content in plant N:S Ratio % **06-05-2022**	Average N Content in plant N:S Ratio % **21-06-2023**	Combined Average N:S Ratio %
Control	2.56	2.82	1.42	2.26
Plot 1	3.19	2.24	1.13	2.18
Plot 2	2.39	2.91	1.65	2.32
Plot 3	2.73	3.06	1.6	2.46

Yield (t/ha):

Year	Control	Plot 1	Plot 2	Plot 3
2020	11.6	11.1	11.2	11.7
2021	10.33	10.34	9.86	10.04
2022	11.46	11.7	11.83	11.98
Average	**11.16**	**11.04**	**10.96**	**11.2**

Protein (%):

Year	Control	Plot 1	Plot 2	Plot 3
2020	12.32	9.44	10.29	11.98
2021	NA	NA	NA	NA
2022	10.79	9.59	11.55	11.98
Average	**10.8**	**10.41**	**11.36**	**11.5**

Porous Pot Results Oct 2020 – Jan 2021:

Control		Plot 1 (5%)		Plot 2 (10%)		Plot 3 (15%)	
Date of sample	**Nitrate (mg/l)**	**Date of sample**	**Nitrate (mg/l)**	**Date of sample**	**Nitrate (mg/l)**	**Date of sample**	**Nitrate (mg/l)**
04/11/2020	2.4	04/11/2020	0.275	04/11/2020	0.1	04/11/2020	0.725
19/11/2020	0.225	19/11/2020	0.2	19/11/2020	0.2	19/11/2020	0.2
03/12/2020	0.1	03/12/2020	0.4	03/12/2020	0.1	03/12/2020	0.1
16/12/2020	0.1	16/12/2020	0.1	16/12/2020	0.333	16/12/2020	0.225
29/12/2020	0.1	29/12/2020	0.1	29/12/2020	0.1	29/12/2020	0.1
14/01/2021	0.375	14/01/2021	0.1	14/01/2021	0.425	14/01/2021	0.1
02/02/2021	0.1	02/02/2021	0.1	02/02/2021	0.1	02/02/2021	0.1
11/02/2022	0.26	11/02/2022	0.8	11/02/2022	0.5	11/02/2022	0.3

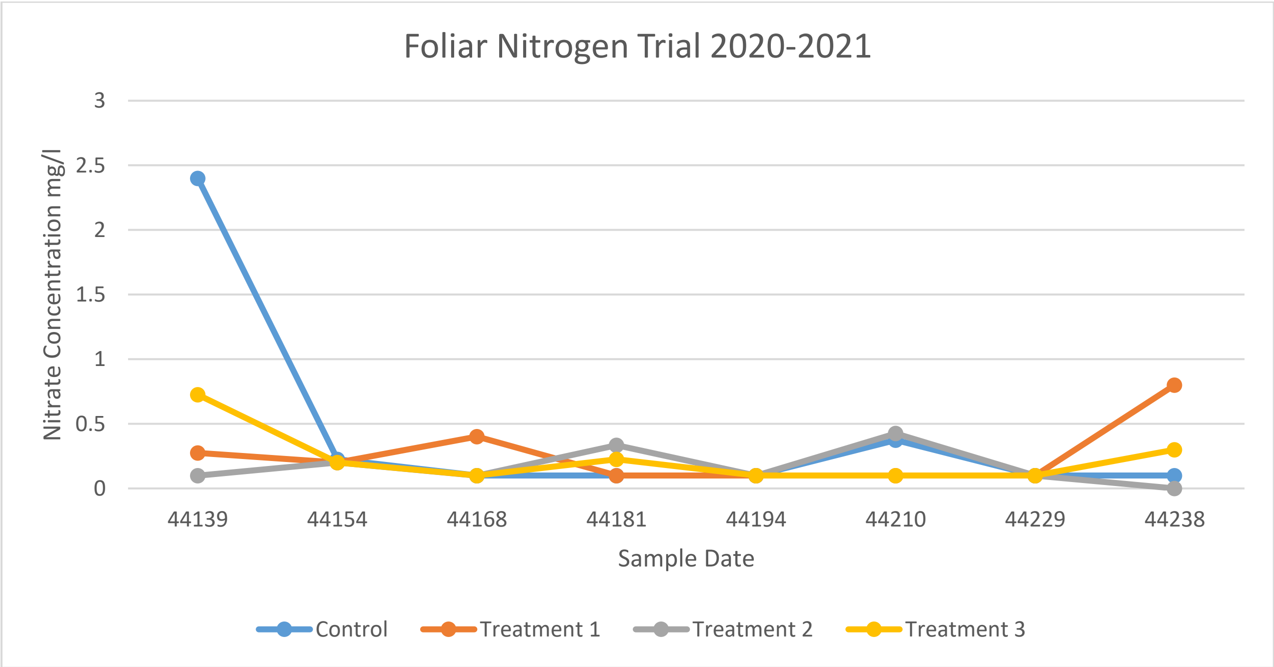


Figure 1. Porous pot results 2020-2021

Porous Pot Results Oct 2021 – Jan 2022:

Control		Plot 1		Plot 2		Plot 3	
Date of sample	**Nitrate (mg/l)**	**Date of sample**	**Nitrate (mg/l)**	**Date of sample**	**Nitrate (mg/l)**	**Date of sample**	**Nitrate (mg/l)**
14/10/2021	4.5	14/10/2021	11.4	14/10/2021	9.5	14/10/2021	20.33
02/11/2021	3.3	02/11/2021	6.85	02/11/2021	9.57	02/11/2021	1.85
11/11/2021	4.23	11/11/2021	3.98	11/11/2021	1.05	11/11/2021	2.1
01/12/2021	6.25	01/12/2021	3.4	01/12/2021	0.23	01/12/2021	8
14/12/2021	1.77	14/12/2021	3.75	14/12/2021	0.13	14/12/2021	6.43
05/01/2022	0.1			05/01/2022	0.1		
11/01/2022	0.7	11/01/2022	0.1	11/01/2022	0.15	11/01/2022	1.65
19/01/2022	0.4			19/01/2022	0.9	19/01/2022	0.2
21/01/2022	0.8					21/01/2022	0.1

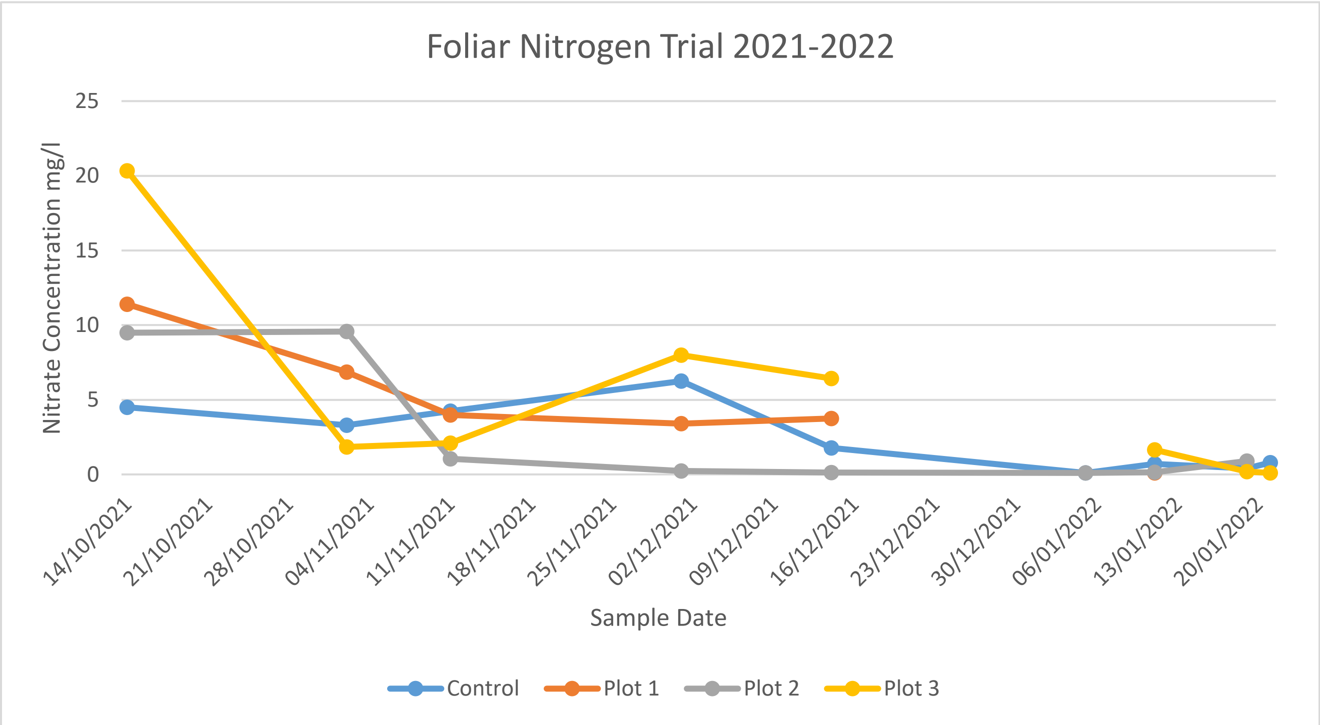


Figure 2. Porous pot results 2021-2022

Porous Pot Results Oct 2022 – Jan 2023:

Control		Plot 1		Plot 2		Plot 3	
Date of sample	**Nitrate (mg/l)**	**Date of sample**	**Nitrate (mg/l)**	**Date of sample**	**Nitrate (mg/l)**	**Date of sample**	**Nitrate (mg/l)**
08/11/2022		08/11/2022	65.2	08/11/2022	16.7	08/11/2022	22.8
17/11/2022	11.95	17/11/2022	19	17/11/2022	8.58	17/11/2022	17.3
30/11/2022	8.38	30/11/2022	9.6	30/11/2022	2.725	30/11/2022	5.85
19/12/2022	3.975	19/12/2022	6.175	19/12/2022	0.875	19/12/2022	3.03
06/01/2023	3.8	06/01/2023	4.5	06/01/2023	1.6	06/01/2023	1.34
18/01/2023	3.55	18/01/2023	2.3	18/01/2023	1.66	18/01/2023	1.025
23/02/2023	4.6	23/02/2023	2	23/02/2023	1.4	23/02/2023	

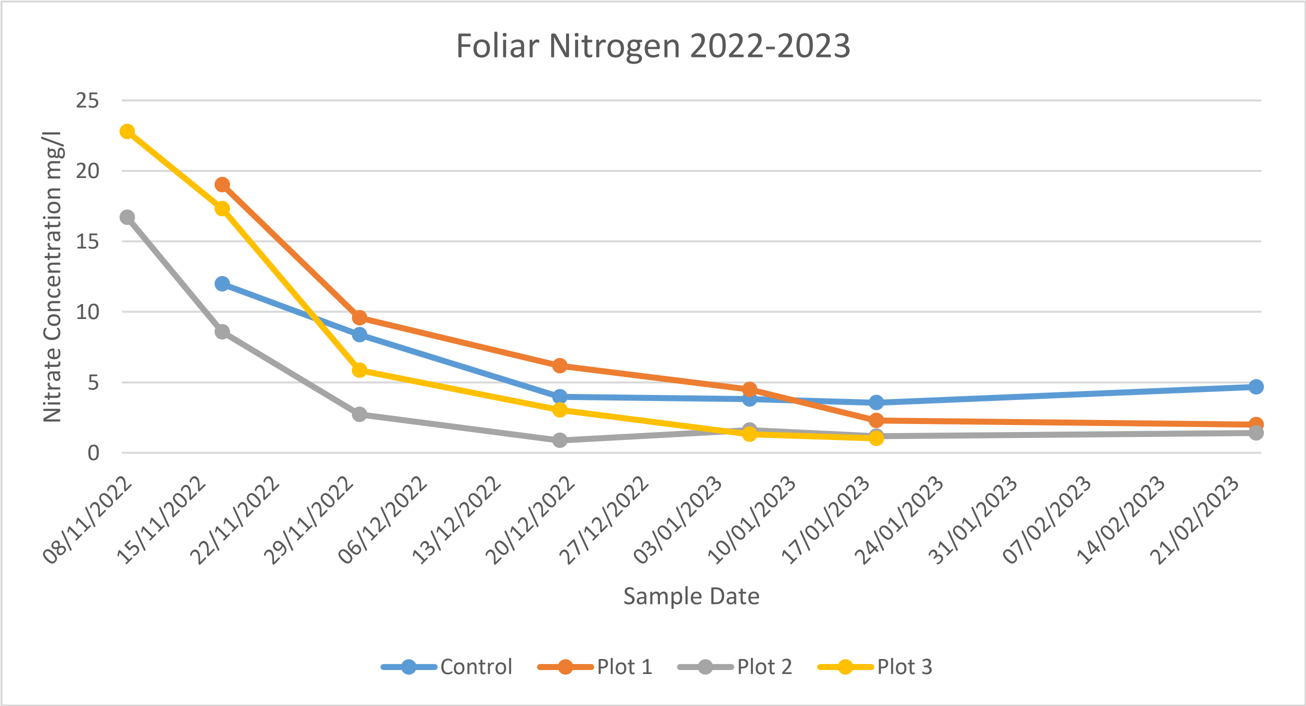


Figure 3. Porous pot results 2022-2023

Results Summary Year 2020:

Plot number	Control	1	2	3
Treatment (Foliar Passes)	**20L @ T3**	**40l @ T2 & 40l @ T3**	**20l @ T1, 20l @ T2 & 20l @ T3**	**316l N19 + 19SO3 320kg/h AN 260 kg AN**
Total N applied (kg N/ha)	227	174	191	260
Nitrogen use efficiency* (%)	51.5	64	58	45
Yield (t/ha)	11.6	11.1	11.2	11.7
Protein Content (%)	12.32	9.44	10.29	11.98
Gross margin incl fert costs** (£/ha)	£1,801	£1,667	£1,701	£1,825
Difference between spring & autumn SMN results (kg available N/ha)	3.9	11.3	-2.4	-0.1

Nitrogen use efficiency = kg grain/ha divided by kg N applied/ha

***** Based on grain price of £170/t and market fertiliser price***

Results Summary Year 2021:

Plot number	Control	1	2	3
Treatment (Foliar Passes)	**316l N19 + 19SO3 290kg/h AN 20l E28 @ T2 130 kg AN**	**20l E28 @ T1.5, T2 & T3**	**316l N19 + 19SO3 290kg/h AN 130 kg AN 20l E28 @ T3**	**316l N19 + 19SO3 290kg/h AN 250 kg AN**
Total N applied (kg N/ha)	212	181	212	244
Nitrogen use efficiency* (%)	49	57	46	41
Yield (t/ha)	10.33	10.34	9.86	10.04
Protein Content (%)	NA	NA	NA	NA
Gross margin incl fert costs** (£/ha)	£1,887	£1,839	£1,759	£1,824
Difference between spring & autumn SMN results (kg available N/ha)	10.8	9.8	14.5	32.1

Nitrogen use efficiency = kg grain/ha divided by kg N applied/ha

***** Based on grain price of £200/t and market fertiliser price***

Results Summary Year 2022:

Plot number	Control	1	2	3
Treatment (Foliar Passes)	**363l N19 + 19SO3 270kg/h AN 20l E28 @ T2 190 kg AN**	**20l E28 @ T1.5, T2 & T3**	**316l N19 + 19SO3 290kg/h AN 130 kg AN 20l E28 @ T3**	**316l N19 + 19SO3 290kg/h AN 250 kg AN**
Treatment (Foliar Passes)	207	161	192	224
Nitrogen use efficiency* (%)	55	73	62	55
Yield (t/ha)	11.46	11.7	11.83	12.43
Protein Content (%)	10.79	9.59	11.55	11.98
Gross margin incl fert costs** (£/ha)	£2,920	£2,873	£2,745	£2,828
Difference between spring & autumn SMN results (kg available N/ha)	36.3	34	52.5	40.5

Nitrogen use efficiency = kg grain/ha divided by kg N applied/ha

***** Based on grain price of £300/t and market fertiliser price***

Conclusions:

The aim of this Foliar N trial was to determine the effectiveness of substituting more traditional fertilisers (granular AN, urea etc.) with a liquid polymer urea product in terms of a reduction in nitrate leaching into the ground water whilst maintaining crop and economic performance.

The data gathered over the past three years has not demonstrated an advantage or disadvantage in nitrate leaching compared to a more traditional fertiliser regime. The application timing, variation between each field plot along with the drastically different weather conditions we have experienced each year are likely to have contributed towards this. Over the past two years there has been significantly more nitrate leaching in the early autumn season where a straight granular fertiliser approach has been taken when compared to the plots with E28 in the program. But considering the greatly reduced N totals in some plots, the trends witnessed are surprising.

Crop performance over the trial has been maintained in terms of yield despite the large variation in nitrogen concentrations applied to the crops of wheat. A variance of 86kgN/ha between plots in 2020 only resulted in 0.6t/ha yield variation. I acknowledge that financially this is considerable, but the yield reduction was not as great as had been expected. However, comparing 1 pass of E28 @ T3 in 2020 against the traditional program (33kgN/ha difference) there was only a 0.1t/ha difference.

When yields are compared over the three-year length of the trial, the variation between the four different treatments reduces even further. The difference between the straight AN (plot 3) and the control (1 pass of E28) is 0.04t (40kg/ha). What is clear is you can only replace so much of the nitrogen within a wheat program with polymer N. Protein levels and yields where multiple passes of E28 have been used are poor, particularly in plot 1 (3 passes of E28). One pass of E28 combined with the T2 fungicide has been the most reliable in terms of yield and protein.

The nitrogen use efficiency has been consistently higher where E28 foliar N has been used compared to the farms standard granular approach.

In financial terms, one pass of E28 with T2 has been marginally stronger financially. Anything more than 1 pass of E28 does not appear to be financially advisable.
**Previously Efficient N28 was very good value £/kgN. Recent prices rises may make this look different, but at the time of the trials the prices are accurate.*

The results of this trial do not demonstrate that foliar nitrogen as a sole solution to reducing nitrogen leaching and reducing the risk of groundwater pollution. However, it has been demonstrated that a nitrogen approach encompassing polymer N products does not hinder the crop performance and economic output can be maintained.

Any questions then please contact Stephen Woodley (stephen@swoodleycropservices.co.uk)