Portsmouth Water Nitrogen Reduction & Foliar N Combined Trial 2020-23

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Catchment Sensitive Farming
Working together for a healthy environment

Portsmouth Water

Introduction:

Why does every farm apply different amounts of Nitrogen fertiliser?

During my early career as an agronomist, I began to realize that every farm has a different plan when it comes to nitrogen fertiliser. The same crop and variety of wheat on the same soil type could see N applications ranging from 220kgN/ha up to 320kgN/ha and the expected yield differences are not always apparent.

With the increasing pressure on the condition of our ground water and the cost of nitrogen fertiliser, it was deemed that we need to improve our understanding of why and how we apply the amounts of N, and to what extent does this impact the crops performance in terms of yield and protein. How do we know we are applying the right amount?

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. Obviously, weather has a massive effect on a wheats potential yield and protein content, so the trial was set to run for three years.

These two trials have been run separately since 2020 and for the first time have been combined in the 2023-2024 season.

The trials:

N – reduction: (Treatments 1-4)

Portsmouth Water commissioned S. Woodley Crop Services to conduct an in-depth trial set to understand and measure the effect cutting back N applications has on a crop of winter wheat in terms of yield (income for the grower) and the reduction in nitrogen leaching into the groundwater. A 5ha field trail site planted each year with winter wheat. A chalk loam soil was chosen. The field was planted with stubble turnips over winter. Four different fertiliser regimes were planned to look to cut back applications.

Foliar N: (Treatments 5-8)

This trial with R.S Payton compares 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)
2. 10% reduction total N
3. 15% reduction total N
4. 20% reduction total N
5. Control (with foliar N E28)
6. 10% reduction total N (with foliar N E28)
7. 15% reduction total N (with foliar N E28)
8. 20% reduction total N (with foliar N E28)

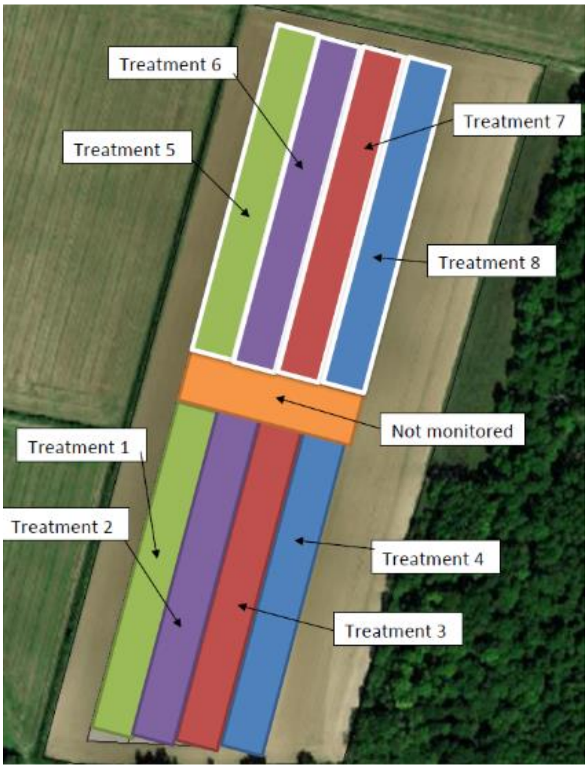


Table 1: Proposed nutrient applications on the trial plots:

Treatment 1: **Control** Normal Fertiliser regime Total N: 260kg N/ha.	Treatment 2: **10% reduction** Two normal applications of granular fertiliser followed by a reduced third application. **Total N: 234kg N/ha**	Treatment 3: **15% reduction** **One** normal application of granular fertiliser followed by a reduced **second** and **third** application. **Total N: 221kg N/ha**	Treatment 4: **20% reduction** **One** normal application of granular fertiliser followed by a reduced **second** and **third** application. **Total N: 208kg N/ha**
60 Kg N/ha (130kg/ha) Urea early/mid-march. 100 Kg N/ha (217kg/ha) Urea granular fertiliser mid-April. 60 Kg N/ha (130kg/ha) Urea granular fertiliser early May. 40 Kg N/ha (130kg/ha) Urea granular fertiliser late May.	60 Kg N/ha (130kg/ha) Urea early/mid-march. 86 Kg N/ha (180kg/ha) Urea granular fertiliser mid-April. 46 Kg N/ha (100kg/ha) Urea granular fertiliser early May. 40 Kg N/ha (130kg/ha) Urea granular fertiliser late May.	60 Kg N/ha (130kg/ha) Urea early/mid-march. 80 Kg N/ha (175kg/ha) Urea granular fertiliser mid-April. 40 Kg N/ha (85kg/ha) Urea granular fertiliser early May. 40 Kg N/ha (130kg/ha) Urea granular fertiliser late May.	60 Kg N/ha (130kg/ha) Urea early/mid-march. 74 Kg N/ha (160kg/ha) Urea granular fertiliser mid-April. 34 Kg N/ha (74kg/ha) Urea granular fertiliser early May. 40 Kg N/ha (130kg/ha) Urea granular fertiliser late May.

Table 1: Proposed nutrient applications on the trial plots continued:

Treatment 5: **Control + 20l E28** Normal Fertiliser regime Total N: 267kg N/ha.	Treatment 6: **10% reduction + 20l E28** Two normal applications of granular fertiliser followed by a reduced third application. **Total N: 241kg N/ha**	Treatment 7: **15% reduction + 20l E28** **One** normal application of granular fertiliser followed by a reduced **second** and **third** application. **Total N: 228kg N/ha**	Treatment 8: **20% reduction + 20l E28** **One** normal application of granular fertiliser followed by a reduced **second** and **third** application. **Total N: 215kg N/ha**
60 Kg N/ha (130kg/ha) Urea early/mid-march. 100 Kg N/ha (217kg/ha) Urea granular fertiliser mid-April. 7KgN/ha **20L/ha E28** polymer N 60 Kg N/ha (130kg/ha) Urea granular fertiliser early May. 40 Kg N/ha (130kg/ha) Urea granular fertiliser late May.	60 Kg N/ha (130kg/ha) Urea early/mid-march. 86 Kg N/ha (180kg/ha) Urea granular fertiliser mid-April. 7KgN/ha **20L/ha E28** polymer N 46 Kg N/ha (100kg/ha) Urea granular fertiliser early May. 40 Kg N/ha (130kg/ha) Urea granular fertiliser late May.	60 Kg N/ha (130kg/ha) Urea early/mid-march. 80 Kg N/ha (175kg/ha) Urea granular fertiliser mid-April. 7KgN/ha **20L/ha E28** polymer N 40 Kg N/ha (85kg/ha) Urea granular fertiliser early May. 40 Kg N/ha (130kg/ha) Urea granular fertiliser late May.	60 Kg N/ha (130kg/ha) Urea early/mid-march. 74 Kg N/ha (160kg/ha) Urea granular fertiliser mid-April. 7KgN/ha **20L/ha E28** polymer N 34 Kg N/ha (74kg/ha) Urea granular fertiliser early May. 40 Kg N/ha (130kg/ha) Urea granular fertiliser late May.

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:

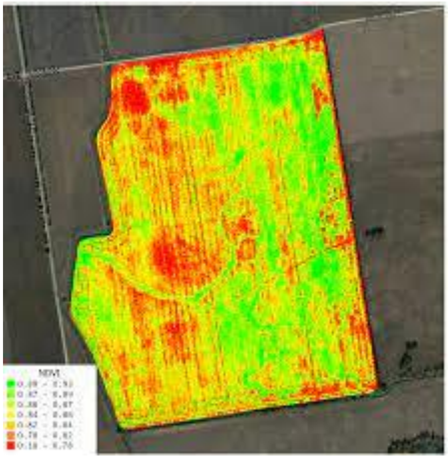
Site visits were made throughout the growing season to determine any differences in wheat growth.

Tissue Samples:

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

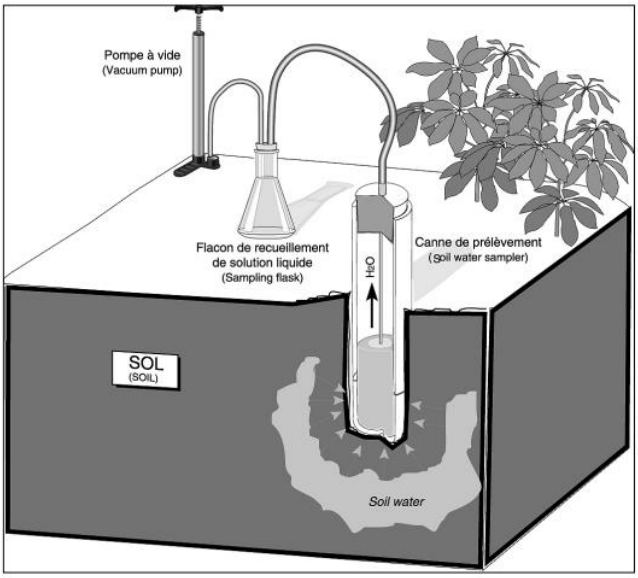
Satellite Biomass Imagery:

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:

Eight porous pots were installed in each treatment, giving a total of 72 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 N-reduction 2020-2021:

Field Reference	Feb 2020 SMN (kgN/ha)	September 2020 SMN (kgN/ha)	January 2021 SMN kgN/ha)
Control	20.4	27.7	25.4
Plot 1 (5%)	20.8	29.5	26.9
Plot 2 (10%)	27.7	30.4	22
Plot 3 (15%)	31.8	24.2	25.8
Plot 4 (20%)	36.9	25.4	85
Average	27.52	27.44	37.02

Table 3: SMN (Soil Mineral Nitrogen) Results Foliar N 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

From the tables above it can be seen that there is no significant difference in the nitrate levels between the control and the trial plots. The result highlighted in red is an outlier and the reason for this could be that the plot is situated downhill of the control which will receive a higher dose of nitrogen. Any leaching will run down hill into plot 4.

Table 4: SMN (Soil Mineral Nitrogen) Results N-reduction 2021-2022:

Field Reference	Feb 2021 SMN (kgN/ha)	September 2021 SMN (kgN/ha)	January 2022 SMN kgN/ha)
Control	28	69.3	27.6
Plot 1 (5%)	30	51	27.9
Plot 2 (10%)	29	52.7	27.8
Plot 3 (15%)	26	29.8	22.8
Plot 4 (20%)	26	67.8	27.6
Average	27.8	54.12	26.74

Table 5: SMN (Soil Mineral Nitrogen) Results Foliar N 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

The SMN results from the N-reduction trial show little difference to the control results and in January 2022, all of the results are close to the average. But as expected the highest residual N level after harvest was in the plot which had the highest N loading applied. The Foliar N trial shows higher Nitrogen levels in the soil by Jan 2022 in all trial plots compared to the control.

Table 6: SMN (Soil Mineral Nitrogen) Results N-reduction 2022-2023:

Field Reference	Feb 2022 SMN (kgN/ha)	September 2022 SMN (kgN/ha)	January 2023 SMN kgN/ha)
Control	50	63	42
Plot 1 (5%)	36	53	37
Plot 2 (10%)	39	72	46
Plot 3 (15%)	61	60	38
Plot 4 (20%)	59	74	30
Average	49	64.4	38.6

Table 7: SMN (Soil Mineral Nitrogen) Results Foliar N 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

Plots 2 & 4 from the N-reduction trial had a higher N level than the control by September 2022 (highlighted in red), but by January there was very little statistical difference observed. All other plots across both trials finished with a lower SMN result than the control.

Table 8: SMN (Soil Mineral Nitrogen) Results N-reduction 2023-2024:

Field Reference	Feb 2023 SMN (kgN/ha)	August 2023 SMN (kgN/ha)	January 2024 SMN kgN/ha)
Plot 1 (Control)	40	74	140
Plot 2 (10%)	41	100	87
Plot 3 (15%)	37	90	93
Plot 4 (20%)	41	82	117
Average	39.75	86.5	109.25

Table 9: SMN (Soil Mineral Nitrogen) Results Foliar N 2023-2024:

Field Reference	Feb 2023 SMN (kgN/ha)	August 2023 SMN (kgN/ha)	January 2024 SMN kgN/ha)
Plot 5 (Control)	37	73	131
Plot 6	47	93	91
Plot 7	38	87	111
Plot 8	41	67	125
Average	40.75	80	114.5

The results from 2023-2024 are higher than any previous year. It is difficult to comprehend why we are witnessing higher levels of N in the reduced nitrogen plots. The results show less N in the soil for all plots compared to the control for both trials after the winter period.

Table 10: Tissue Sample Results N-reduction 2020:

SAMPLE	N Reduction %	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	0	4.17	3.92	1.59	3.23
Plot 1	5	4.18	3.95	1.71	3.28
Plot 2	10	4.51	3.96	1.85	3.44
Plot 3	15	4.59	3.84	1.75	3.39
Plot 4	20	4.65	3.78	1.64	3.36

Table 11: Tissue Sample Results Foliar N 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 12: Tissue Sample Results N-reduction 2021:

SAMPLE	N Reduction %	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	0	3.76	3.42	2.18	3.12
Plot 1	5	3.67	2.84	2.32	2.94
Plot 2	10	3.65	3.1	2.28	3.01
Plot 3	15	3.66	2.61	1.81	2.69
Plot 4	20	3.83	2.98	2.29	3.03

Table 13: Tissue Sample Results Foliar N 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 14: Tissue Sample Results N-reduction 2022:

SAMPLE	N Reduction %	Average N Content in plant N:S Ratio % **05-04-2022**	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	0	2.61	2.45	1.58	2.21
Plot 1	5	2.74	2.32	1.67	2.24
Plot 2	10	3.09	2.14	1.8	2.34
Plot 3	15	2.59	2.48	1.55	2.21
Plot 4	20	2.57	2.3	1.42	2.1

Table 15: Tissue Sample Results Foliar N 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

Table 16: Tissue Sample Results N-reduction 2023:

SAMPLE	N Reduction %	Average N Content in plant N:S Ratio % **03-05-2023**	Average N Content in plant N:S Ratio % 24**-05-2023**	Average N Content in plant N:S Ratio % **14-06-2023**	Combined Average N:S Ratio %
Plot 1 (Control)	0	2.9	2.29	1.53	2.24
Plot 2 (10%)	10	2.72	2.16	1.71	2.19
Plot 3 (15%)	15	2.9	2.32	1.62	2.28
Plot 4 (20%)	20	2.68	2.16	1.45	2.09

Table 17: Tissue Sample Results Foliar N 2023:

SAMPLE	Average N Content in plant N:S Ratio % **03-05-202**	Average N Content in plant N:S Ratio % 24**-05-2023**	Average N Content in plant N:S Ratio % **14-06-2023**	Combined Average N:S Ratio %
Plot 5 (Control)	2.25	2.24	1.56	2.01
Plot 6	2.07	2.07	1.55	1.89
Plot 7	2.16	2.06	1.45	1.89
Plot 8	2.16	1.94	1.56	1.88

Table 18: N-reduction Yield (t/ha):

Year	Control	Plot 1 (5%-)	Plot 2 (10% -)	Plot 3 (15%-)	Plot 4 (20%-)
2020	13.2	13.02	13.18	12.39	12.6
2021	9.8	9.97	9.6	9.82	9.5
2022	11.46	11.45	11.13	11.54	11.3
2023	10.94	NA	10.63	10.26	9.63
Average	**11.35**	**11.48**	**11.13**	**11.00**	**10.75**

Table 19: N-reduction Protein (%):

Year	Control	Plot 1 (5%-)	Plot 2 (10% -)	Plot 3 (15%-)	Plot 4 (20%-)
2020	10.82	11.23	11.17	11.02	11.58
2021	12.88	12.21	11.48	11.26	10.77
2022	13.45	12.84	13.22	12.3	11.63
2023	12.98	NA	12.91	12.58	12.30
Average	**12.53**	**12.09**	**12.19**	**11.79**	**11.57**

The data above shows that the yield has not been significantly affected by the reduced nitrogen fertiliser until plot 4 with the 20% reduction. The protein percentage is impacted directly. The more Nitrogen applied, the higher the protein percentage. There appears to be some discrepancy between the 5% reduction and the 10% reduction, where this rule does not apply.

Table 20: Foliar N 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
2023	11.12	10.12	10.37	10.12
Average	**11.12**	**10.81**	**10.81**	**10.96**

Table 21: Foliar N 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
2023	12.65	11.95	12.9	11.9
Average	**11.92**	**10.32**	**11.58**	**11.95**

Similar to the N-reduction trial, the Yield results are not significantly different. The protein results show a similar pattern, apart from plot 1, that has a much lower average.

Porous Pot Results N-reduction Oct 2020 – Jan 2021:

Control		Plot 1 (5%)		Plot 2 (10%)		Plot 3 (15%)		Plot 4 (20%)	
Date of sample	**Nitrate (mg/l)**	**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	8.1	04/11/2020	0.1	04/11/2020	12	04/11/2020	3.5	04/11/2020	2
19/11/2020	6.65	19/11/2020	4.625	19/11/2020	0.6	19/11/2020	10.3	19/11/2020	1.775
03/12/2020	2.1	03/12/2020	0.3	03/12/2020	0.5	03/12/2020	1.725	03/12/2020	0.1
16/12/2020	1.15	16/12/2020	0.2	16/12/2020	0.1	16/12/2020	0.1	16/12/2020	0.1
29/12/2020	0.1	29/12/2020	0.1	29/12/2020	0.1	29/12/2020	0.1	29/12/2020	0.1
14/01/2021	0.6	14/01/2021	0.1	14/01/2021	0.1	14/01/2021	0.1	14/01/2021	0.1
02/02/2021	0.1	02/02/2021	0.125	02/02/2021	0.1	02/02/2021	0.1	02/02/2021	0.1
11/02/2022	0.26	11/02/2022	0.975	11/02/2022	0.5	11/02/2022	1.13	11/02/2022	0.1

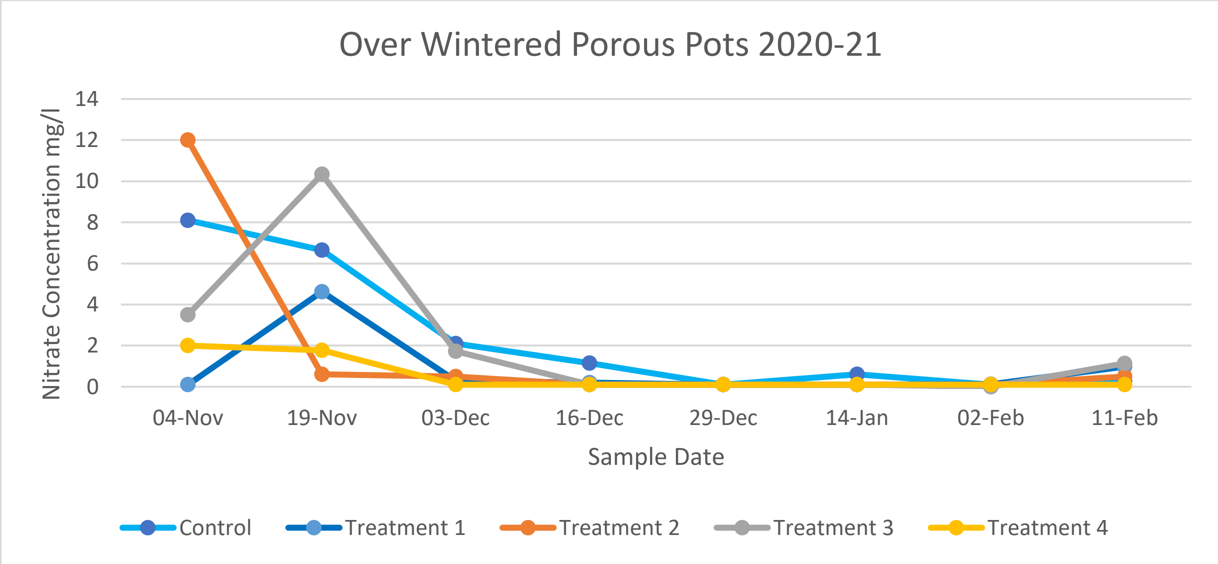


Figure 1. Porous pot results N-reduction 2020-2021

Porous Pot Results Foliar N 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

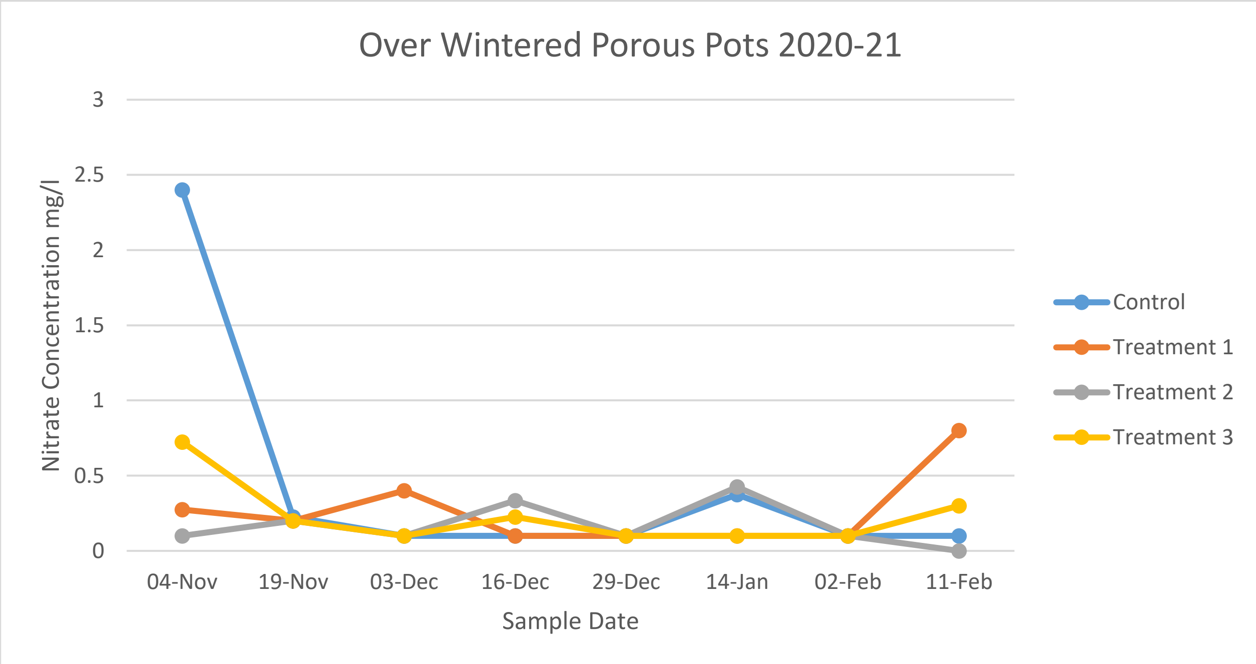


Figure 2. Porous pot results Foliar N 2020-2021

Porous Pot Results N-reduction Oct 2021 – Jan 2022:

Control		Plot 1 (5%)		Plot 2 (10%)		Plot 3 (15%)		Plot 4 (20%)	
Date of sample	**Nitrate (mg/l)**	**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	29.68	14/10/2021	22.9	14/10/2021	12.4	14/10/2021	19.07	14/10/2021	8.53
11/11/2021	14.27	11/11/2021	12.75	11/11/2021	10.33	11/11/2021	9.25	11/11/2021	3.8
01/12/2021	18.7	01/12/2021	15.17						
14/12/2021	4	14/12/2021	8.85	14/12/2021	0.25				
05/01/2022	0.1	05/01/2022	1	05/01/2022	0.4	05/01/2022	1.9	05/01/2022	0.1
11/01/2022	9.93	11/01/2022	0.1			11/01/2022	0.2	11/01/2022	0.3
21/01/2022	1.87	21/01/2022	0.1	21/01/2022	0.85			21/01/2022	0.1

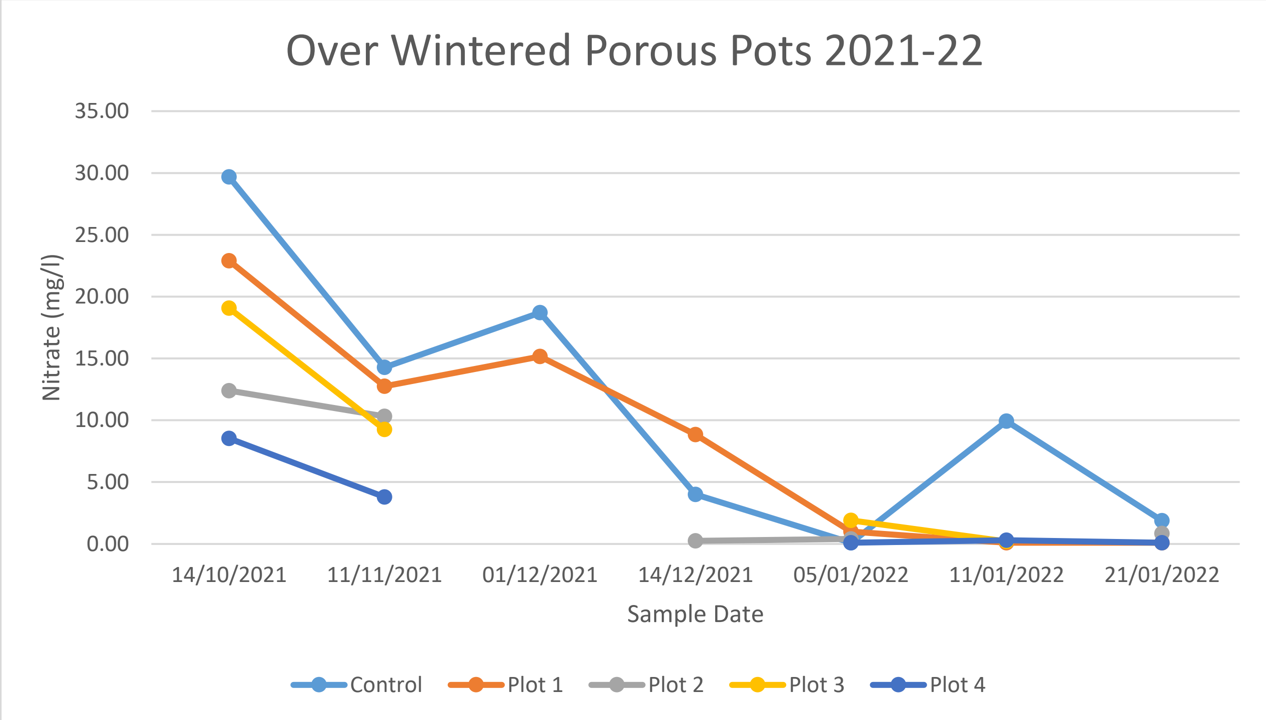


Figure 3. Porous pot results N-reduction 2021-2022

Porous Pot Results Foliar N 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

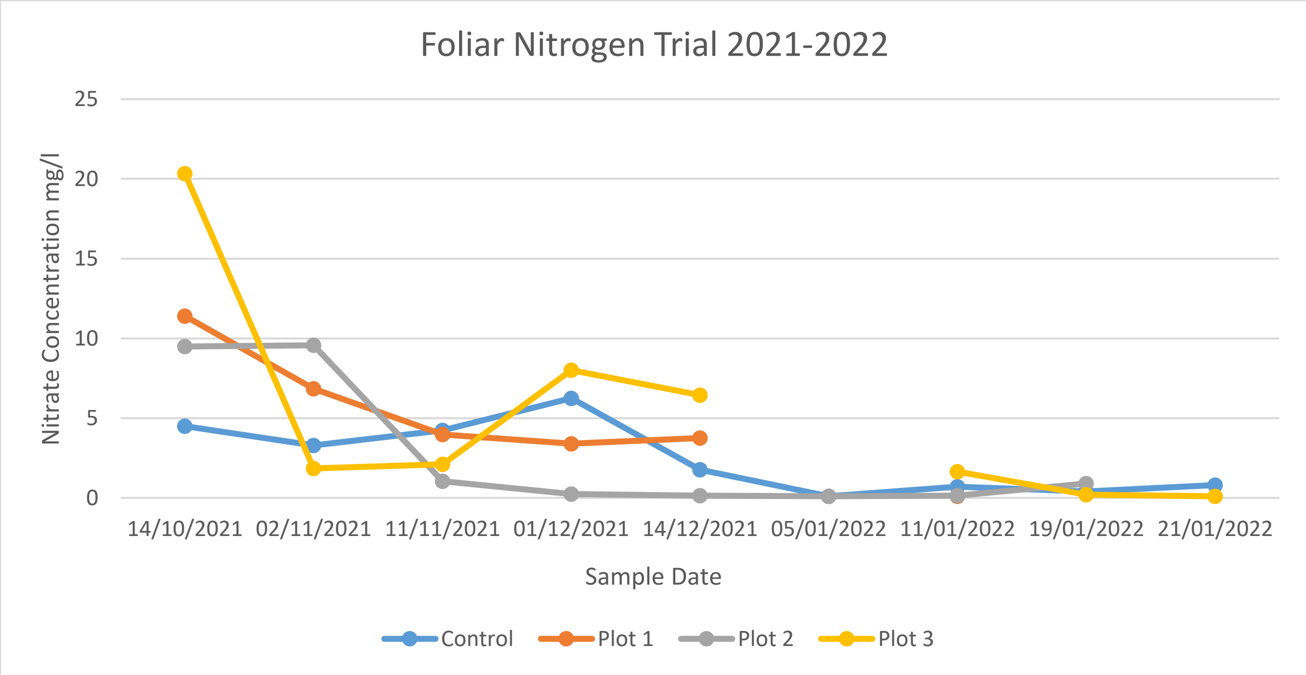


Figure 2. Porous pot results Foliar N 2021-2022

Porous Pot Results N-reduction Oct 2022 – Jan 2023:

Control		Plot 1 (5%)		Plot 2 (10%)		Plot 3 (15%)		Plot 4 (20%)	
Date of sample	Nitrate (mg/l)	Date of sample	Nitrate (mg/l)	Date of sample	Nitrate (mg/l)	Date of sample	Nitrate (mg/l)	Date of sample	Nitrate (mg/l)
17/11/2022	12.65	17/11/2022	8.90	17/11/2022		17/11/2022	4.20	17/11/2022	2.68
30/11/2022	11.33	30/11/2022	5.03	30/11/2022	3.10	30/11/2022	3.43	30/11/2022	1.67
19/12/2022	7.30	19/12/2022	3.43	19/12/2022	1.37	19/12/2022	3.18	19/12/2022	1.43
06/01/2023	11.33	06/01/2023	3.20	06/01/2023	2.13	06/01/2023	3.05	06/01/2023	1.70
18/01/2023	6.45	18/01/2023	3.88	18/01/2023	5.15	18/01/2023	5.83	18/01/2023	2.97
23/02/2023	7.57	23/02/2023	6.70	23/02/2023	7.77	23/02/2023	5.43	23/02/2023	7.40

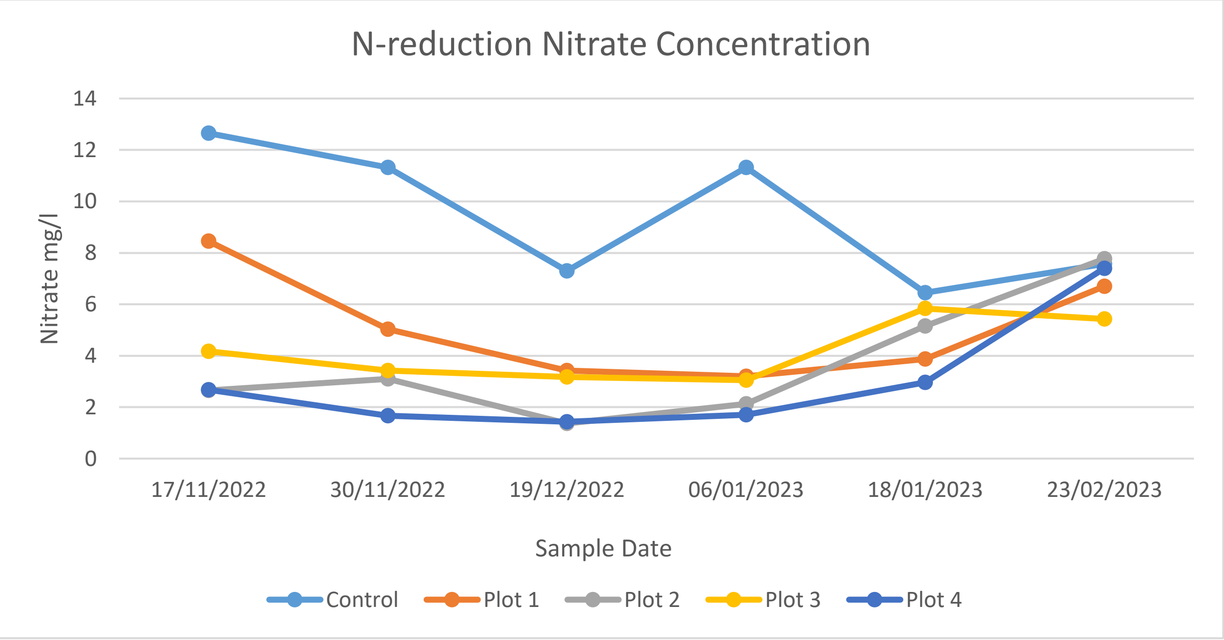


Figure 3. Porous pot results N-reduction 2022-2023

Porous Pot Results Foliar N 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	

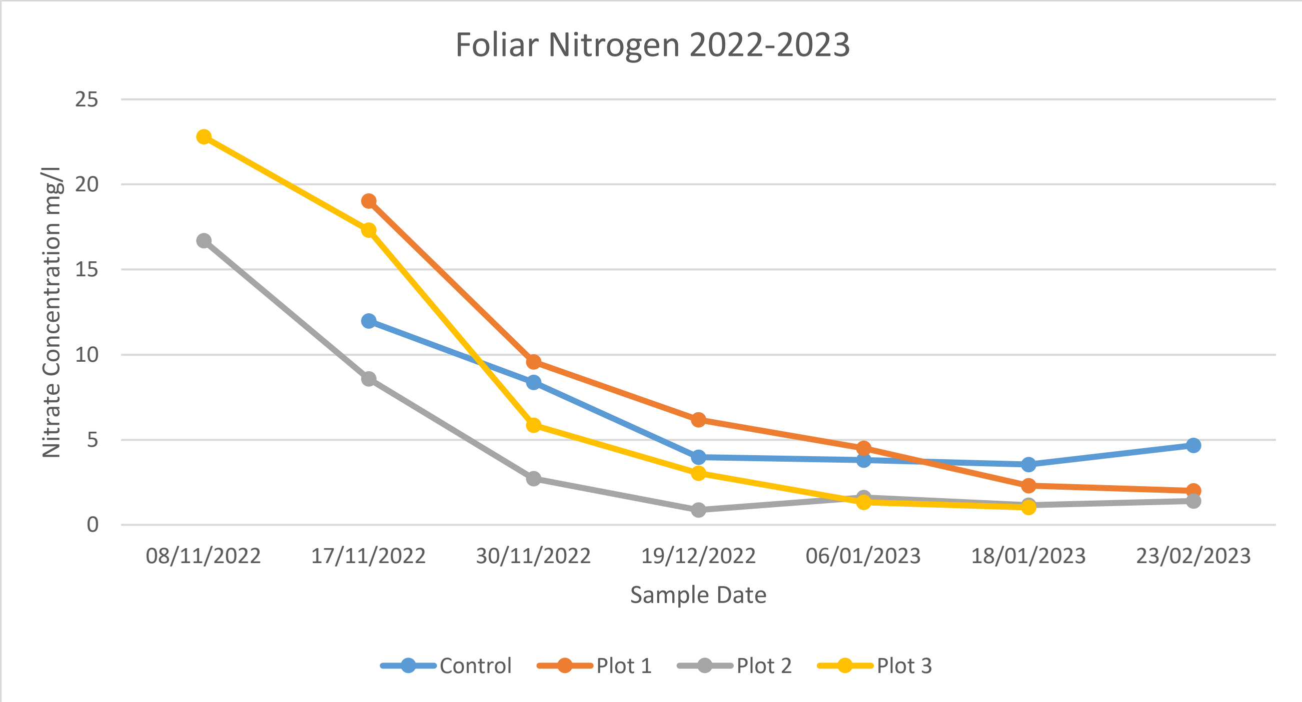


Figure 3. Porous pot results Foliar N 2022-2023

Porous Pot Results N-reduction Oct 2023 – Jan 2024:

Treatment 1 (Control)		Treatment 2 (10%)		Treatment 3 (15%)		Treatment 4 (20%)	
Date of Sample	Nitrate (mg/l)	Date of Sample	Nitrate (mg/l)	Date of Sample	Nitrate (mg/l)	Date of Sample	Nitrate (mg/l)
16/11/2023	2.8	16/11/2023	0.1	16/11/2023	1.5	16/11/2023	1.4
29/11/2023	3.275	29/11/2023	1.42	29/11/2023	2.04	29/11/2023	4.433333333
15/12/2023	4.9	15/12/2023	1.925	15/12/2023	2.22	15/12/2023	1.633333333
05/01/2024	5.2	05/01/2024	2.95	05/01/2024	3.55	05/01/2024	3.7
12/01/2023	12.85	12/01/2023	10.45	12/01/2023	7.7	12/01/2023	11.73333333
20/02/2024	10.45	20/02/2024	8.05	20/02/2024	13.13333333	20/02/2024	22.3

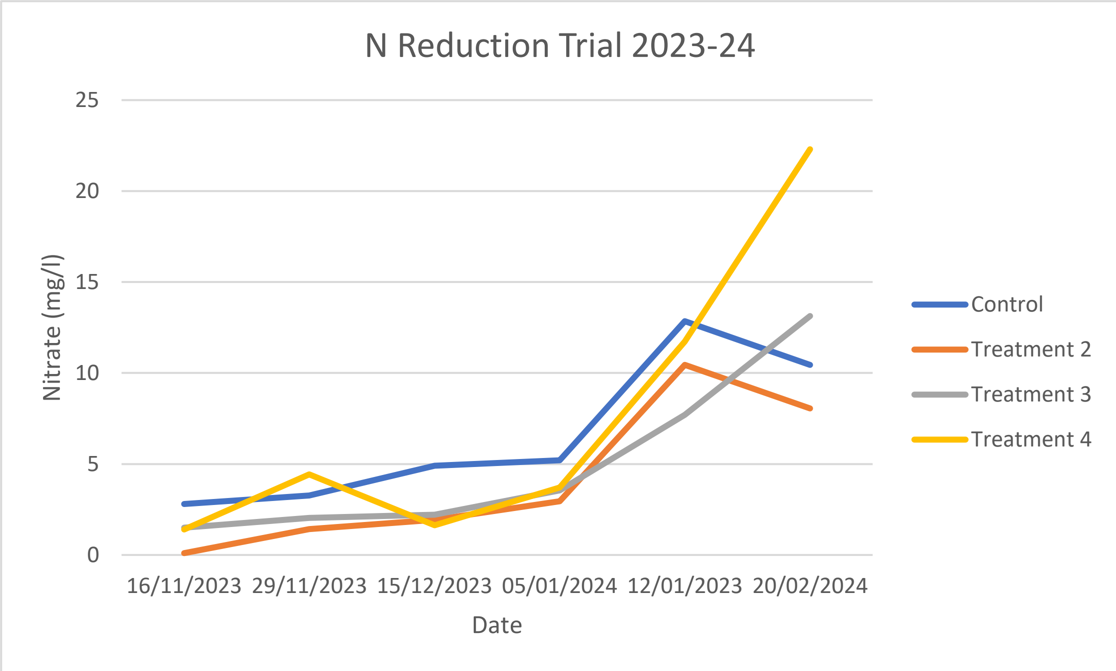


Figure 3. Porous pot results Foliar N 2022-2023

Porous Pot Results Foliar N Oct 2023 – Jan 2024:

Treatment 5 (Control)		Treatment 6 (10%)		Treatment 7 (15%)		Treatment 8 (20%)	
Date of Sample	Nitrate (mg/l)	Date of Sample	Nitrate (mg/l)	Date of Sample	Nitrate (mg/l)	Date of Sample	Nitrate (mg/l)
16/11/2023	1.1	16/11/2023	0.566666667	16/11/2023	7.4	16/11/2023	4.866666667
29/11/2023	1.133333333	29/11/2023	0.9	29/11/2023	5.025	29/11/2023	2.5
15/12/2023	2.7	15/12/2023	2.175	15/12/2023	3.86	15/12/2023	3.5
05/01/2024	8.8	05/01/2024	2.825	05/01/2024	5.6	05/01/2024	3.05
12/01/2023	10.6	12/01/2023	5.966666667	12/01/2023	7.2	12/01/2023	5.95
20/02/2024	9.433333333	20/02/2024	10.06	20/02/2024	16.46666667	20/02/2024	8.86

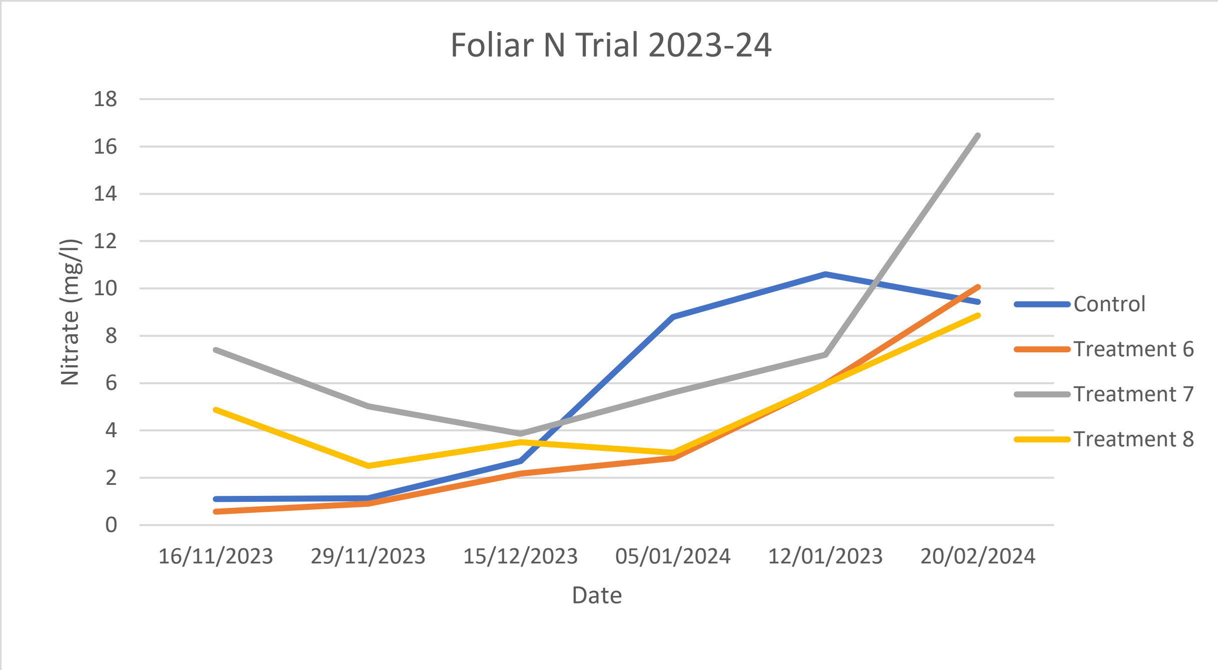


Figure 3. Porous pot results Foliar N 2022-2023

Results Summary N-reduction Year 2020:

Plot number	Control	1	2	3	4
Treatment (% reduction N)	**0% (control)**	**5%**	**10%**	**15%**	**20%**
Total N applied (kg N/ha)	280	266	252	238	224
Nitrogen use efficiency* (%)	47	49	52.3	52.05	56.25
Yield (t/ha)	13.2	13.02	13.18	12.39	12.6
Protein Content (%)	10.82	11.23	11.17	11.02	11.58
Gross margin incl fert costs** (£/ha)	£2,067	£2,045	£2,081	£1,956	£2,000
Difference between spring & autumn SMN results (kg available N/ha)	7.3	8.7	2.7	-7.6	-11.5

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 Foliar N 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 N-reduction Year 2021:

Plot number	Control	1	2	3	4
Treatment (% reduction N)	**0% (control)**	**5%**	**10%**	**15%**	**20%**
Total N applied (kg N/ha)	280	266	252	238	224
Nitrogen use efficiency* (%)	35	37.4	38	41.2	42.4
Yield (t/ha)	9.8	9.97	9.6	9.82	9.5
Protein Content (%)	12.88	12.21	11.48	11.26	10.77
Gross margin incl fert costs** (£/ha)	£1,767	£1,811	£1,746	£1,800	£1,745
Difference between spring & autumn SMN results (kg available N/ha)	48.9	30.2	25	-2	30.9

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 Foliar N 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 N-reduction Year 2022:

Plot number	Control	1	2	3	4
Treatment (% reduction N)	**0% (control)**	**5%**	**10%**	**15%**	**20%**
Total N applied (kg N/ha)	257	244	231	218	205
Nitrogen use efficiency* (%)	44	47	48	53	55
Yield (t/ha)	11.46	11.45	11.13	11.54	11.3
Protein Content (%)	13.45	12.84	13.22	12.3	11.63
Gross margin incl fert costs** (£/ha)	£2,469	£2,550	£2,462	£2,551	£2,479
Difference between spring & autumn SMN results (kg available N/ha)	42.6	32.2	44.3	28.2	37.1

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

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

Results Summary Foliar N 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***

Results Summary N-reduction Year 2024:

Plot number	Control	2	3	4
Treatment (% reduction N)	**0% (control)**	**10%**	**15%**	**20%**
Total N applied (kg N/ha)	260	232	221	208
Nitrogen use efficiency* (%)	42	46	46	46
Yield (t/ha)	10.94	10.63	10.26	9.63
Protein Content (%)	12.98	12.91	12.58	12.03
Gross margin incl fert costs** (£/ha)	£2,826	£2,770	£2,678	£2,514
Difference between spring & autumn SMN results (kg available N/ha)	34	59	53	41

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

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

Results Summary N Reduction + Foliar N Year 2024:

Plot number	5	6	7	8
Treatment (Foliar Passes)	**0% (control) + 20L/ha E28**	**10% + 20L/ha E28**	**15% + 20L/ha E28**	**20% + 20L/ha E28**
Treatment (Foliar Passes)	267	241	228	215
Nitrogen use efficiency* (%)	42	42	45	47
Yield (t/ha)	11.12	10.12	10.37	10.12
Protein Content (%)	12.65	11.95	12.9	11.9
Gross margin incl fert costs** (£/ha)	£2,796	£2,553	£2,665	£2,609
Difference between spring & autumn SMN results (kg available N/ha)	36	46	49	26

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

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

Foliar fertiliser (E28) Conclusions:

The aim of these trials has been 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. It has also explored the effect of reduction total nitrogen has in terms of yield, grain quality (protein) and the financial consequences to the grower.

The data gathered over the past four 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.

The 2024 trial provided and opportunity to see if the application of E28 can take up some of the “slack” from a reduction in granular nitrogen fertiliser. The addition of efficient E28 on the control plot added an extra 0.18t/ha compared to the straight granular application and there was a slight yield uplift in plots 7 & 8 compared to plots 3 & 4. Only plot 8 saw enough of a yield lift to justify the additional cost the E28 @ T2.

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.

Nitrogen Reduction Conclusions:

Reducing nitrogen applications in wheat has rightfully always been a controversial topic with growers and agronomists. The past four years has allowed us to put this to the test, exploring wheat's reaction to reduced inputs of artificial nitrogen in terms of yield and ultimately protein levels within the grain. Improving our understanding of how a plant reacts to reduce levels of nitrogen provides valuable information for both the agronomist and grower, allowing an easily visible consequence in terms of yield, protein and ultimately the financial return. With fertiliser prices in 2022 hitting a record high, weighing up the risk of applying large quantities of N on a wheat crop have never had so much focus.

The data gathered over the past four years has demonstrated a yield reduction as a direct result of cutting back nitrogen applications. Although it is worth noting that this reaction has not been anything like as drastic as has initially been expected. On average the yield reduction with a 20% nitrogen cut has been 0.6t/ha, with the biggest drop in 2024. A similar trend has been seen with protein levels within the grain. A steady decline directly related to the reduced nitrogen application levels. 1% protein with a 20% N reduction (56kgN/ha).

In financial terms, when the protein bonus is not considered (this is on appropriate in (control plot 2021, control 2022 & plot 2 in 2022), the differences in terms of gross margin once the nitrogen price has been considered is not as drastic as one would expect. The differences between the most profitable plot and least in 2020 was £111, 2021 £66, 2022 £89 and in 2024 it was £312. On average the most profitable plot over the three-year trial has been the 5% N reduction, followed by 15%, narrowly more profitable than the control. A useful observation when discussing nitrogen application rates with growers.

If protein is considered, then there is of course quite a big difference, but the problem of chasing the higher protein is it is never a guaranteed premium.

This trial has also set out to improve our understanding of the relationship between reduced nitrogen applications on a crop of wheat and the consequence in terms of nitrate leaching through the soil profile. This has been measured using soil mineral nitrogen samples and over wintered porous pots installed in September and monitored through until February. The SMN data proves to be inconclusive in pinpointing a direct relationship between N applied and residual N after harvest.

However, the porous pot data clearly shows an elevated nitrate concentration within the soil profile following the higher N applications. This has been witnessed in all four years, with the control plots having the highest nitrate concentrations, followed by plot 1 (5% reduction). This links nicely with the nitrogen use efficiency of the crop.

Any questions then please contact Stephen Woodley
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