NEWCASTLE UNIVERSITY

SCHOOL OF AGRICULTURE, FOOD AND RURAL DEVELOPMENT

Report of an Experiment to Evaluate the use of Less-N on a grassland site at Cockle Park in Northumberland, UK

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Introduction:

A field experiment was conducted in the summer of 2009 to evaluate the efficacy of Less-N when applied to an established grassland sward. This report presents results of that experiment in terms of effects on herbage Dry Matter (DM) yield, herbage nitrogen (N) concentration, and estimated N uptake in the herbage.

Treatments applied:

Six experimental treatments were applied. These were all combinations of:

Urea fertilizer application rates

No urea applied
40 kg Urea / hectare (equivalent to18.4 kg N/ha)
80 kg Urea / hectare (equivalent to 36.8 kg N/ha)

Less-N application rates

No Less-N applied
Less-N applied at the recommended rate (3 L/ha)

Experimental design:

All six treatments were replicated five times in a randomised block design. There were therefore 30 plots in total.

Experimental site:

The experiment was sited in the field known as Hanging Leaves at Cockle Park Farm near Morpeth in Northumberland. The sward was an established perennial ryegrass / white clover ley on a boulder clay soil of the Hallsworth series.
After a light spring grazing, the field had been used to provide a first cut of silage, and the experiment was established by applying the fertiliser treatments immediately after the first cut had been removed. Marking out of the site and treatment application took place on 8 June 2009.

Plot size:

Individual plots were 3m wide by 10m long. Each replicate block consisting of 6 treatments was therefore 18m by 10m.

Method of treatment application:

In the laboratory, solutions were made up with the appropriate ingredients for each treatment. Plots receiving no urea received 600 ml of water either with or without Less-N added. Plots receiving 40 kg Urea per hectare had 120 g urea dissolved in 600 ml of water, also with or without Less-N. For plots receiving 80 kg urea per hectare, 240 g were dissolved in 600 ml water.
In the field, the appropriate solutions were applied to each plot using a knapsack sprayer operated by an experienced technician.

Sampling programme:

The plots were sampled at approximately 2, 4 and 6 weeks after treatment application. The exact sampling dates were, Day 14 (22 June), Day 30 (8 July) and Day 42 (20 July). On each occasion the following activities were performed:

Estimation of Herbage mass (kg DM/ha)

1) By clipping sample quadrats

Two sample quadrats, each 0.5 x 0.5 m were distributed at random within the plot and the herbage within was clipped close to ground level using electrically powered sheep shears. The clipped herbage was bulked into one labelled and sealed plastic bag for each plot and removed to the laboratory for subsequent analysis. At the laboratory, the total fresh weight of the sample was recorded, then either the whole sample, or a weighed sub-sample was dried overnight in a forced draught oven. The dried sample was re-weighed to determine the herbage DM concentration. Estimated dry mass was calculated from these data by multiplication.

2) By using the Grassmaster II capacitance meter (Novel Ways Ltd, New Zealand supplied by Donaghys Industries Ltd).

The meter was used as instructed to estimate herbage cover by taking spot readings at ten sites per plot (avoiding quadrat sample areas) then averaging the estimates to give a single reading per plot.

Estimation of herbage nitrogen concentration

The dried herbage samples from the clipping process described above were then passed through a hammer mill, and the resultant dry powder was stored in a sealed envelope for subsequent nitrogen analysis. Samples were analysed using a Leco analyser, operated by an experienced technician. Values are presented as the concentration (%) of nitrogen in the sample Dry Matter.

Estimation of herbage nitrogen uptake

This has been calculated as the product of dry matter yield and herbage N %. It indicates the amount of nitrogen taken up in the foliage in terms of kg N per hectare.

Statistical analysis:

Data were analysed using analysis of variance. The design was a randomised block design with two factors (N rate and additive) factorially combined, and five replicate blocks. Differences between treatments were deemed to be statistically significant when the probability of them occurring by chance was less than 5%.

In the tables within the results section of this document, values shown in parentheses are the standard errors of the treatment means. The analysis of variance tables are presented in appendices 1 to 4.

Results:

Herbage dry matter (DM) yield estimated by clipping

On Day 14 (table 1.1) regrowth had just begun after the previous defoliation and all values for herbage mass were small. In terms of DM yield, there were no consistent effects of urea application rate but the addition of LessN produced a statistically significant yield increase.

Table 1.1 Herbage yields (kg DM/ha) estimated by clipping on Day 14 (22 June 2009)

	Urea Rate (kg/ha)			
	0	40	80	Mean (±59.4)
No Less-N	708	657	608	658a
With Less-N	807	884	822	838b
Mean (±72.8)	757	770	715	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

By Day 30, (table 1.2), a more predictable outcome was apparent. There was a consistent and statistically significant positive effect of urea application. The mean effect of LessN was also positive but on this occasion the difference was not statistically significant.

Table 1.2 Herbage yields (kg DM/ha) estimated by clipping on Day 30 (8 July 2009)

	Urea Rate (kg/ha)			
	0	40	80	Mean (±75.1)
No Less-N	1254	1434	1950	1546a
With Less-N	1266	1712	1942	1640a
Mean (±92.0)	1260	1573	1946	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

On Day 42 (table 1.3) there were clear and statistically significant positive effects of both urea application and LessN application on herbage dry matter yield.

Table 1.3 Herbage yields (kg DM/ha) estimated by clipping on Day 42 (20 July 2009)

	Urea Rate (kg/ha)			
	0	40	80	Mean (±171.2)
No Less-N	2466	3031	3835	3111a
With Less-N	3264	3272	4333	3623b
Mean (±209.7)	2865	3151	4084	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

Herbage dry matter yields estimated by pasture meter

These results, presented in tables 2.1, 2.2 and 2.3 have previously been presented in an earlier interim report.

Estimates of herbage mass were greater than those estimated by clipping, especially on the first sampling occasion. However, on any sampling date, the comparisons between treatments were in line with those from clipping. On Day 14, (table 2.1) there were small positive effects of both urea and LessN application. The effects of urea application were statistically significant whereas the effects of LessN were not.

Table 2.1 Herbage yield (kg DM/ha) estimated by using the pasture meter on Day 14 (22 June 2009)

	Nil N	40 kg Urea	80 kg Urea	Mean (±23.5)
No LessN	1733	1896	2006	1878a
Plus LessN	1708	1962	2035	1902a
Mean (±28.8)	1720	1929	2020	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

By Day 30 (table 2.2), the effects of urea had become more marked and they were statistically significant. There appeared to be a smaller positive effect of LessN, but it was not statistically significant.

Table 2.2 Herbage yield (kg DM/ha) estimated by using the pasture meter on Day 30 (8 July 2009)

	Nil N	40 kg Urea	80 kg Urea	Mean (±60.2)
No LessN	3033	3346	3703	3361a
Plus LessN	3085	3520	3863	3489a
Mean (±73.8)	3059	3433	3783	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

This trend continued on Day 42 (table 2.3) when the effect of urea was substantial and again clearly statistically significant. The effect of LessN was smaller but still positive, though not statistically significant. LessN appeared to increase DM yield whether or not urea had been applied, suggesting that it may have influenced the availability of N from the soil.

Table 2.3 Herbage yield (kg DM/ha) estimated by using the pasture meter on Day 42 (20 July 2009)

	Nil N	40 kg Urea	80 kg Urea	Mean (±63.0)
No LessN	3476	3976	4438	3963a
Plus LessN	3548	4029	4797	4125a
Mean (±77.2)	3512	4002	4617	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

Nitrogen concentration (%) in the herbage DM

These results are presented in tables 3.1, 3.2 and 3.3.

On Day 14, when regrowth had only just begun, herbage N concentration was positively and significantly influenced by urea application, but the effect of LessN was small and inconsistent (table 3.1). This might have been expected because N uptake has previously been shown to occur ahead of DM growth, and it seems here that plots receiving urea application had indeed taken up N but were not yet fully responding in terms of DM production.

Table 3.1 Nitrogen concentration (%) of herbage Dry Matter on Day 14 (22 June 2009)

	Urea Rate (kg/ha)			
	0	40	80	Mean (±0.068)
No Less-N	1.46	1.92	2.45	1.94a
With Less-N	1.35	1.94	2.51	1.93a
Mean (±0.084)	1.40	1.93	2.48	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

By Day 30, the effect of urea application was less marked but still statistically significant. The effect of LessN was small but positive though not statistically significant (table 3.2).

Table 3.2 Nitrogen concentration (%) of herbage Dry Matter on Day 30 (8 July 2009)

	Urea Rate (kg/ha)			
	0	40	80	Mean (±0.043)
No Less-N	1.79	1.79	1.92	1.83a
With Less-N	1.83	1.88	2.09	1.93a
Mean (±0.053)	1.81	1.83	2.00	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

By Day 42, the rate of DM production must have been exceeding that of N uptake because the N% was lower in all treatments than it had been on the previous sampling occasion. Nevertheless, there was still a small, statistically significant effect of urea. The effect of LessN, though positive, was not significant.(table 3.3).

Table 3.3 Nitrogen concentration (%) of herbage Dry Matter on Day 42 (20 July 2009)

	Urea Rate (kg/ha)			
	0	40	80	Mean (±0.033)
No Less-N	1.42	1.56	1.62	1.53a
With Less-N	1.49	1.62	1.72	1.61a
Mean (±0.040)	1.45	1.59	1.67	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

Nitrogen uptake (KgN per hectare)

The results in tables 4.1, 4.2 and 4.3 provide clear evidence that herbage nitrogen uptake was stimulated by urea application on all three occasions. The effect was statistically significant on each sampling date. This is entirely to be expected. The results also demonstrate a consistently positive effect of LessN on nitrogen uptake. This effect was statistically significant on the first and third sampling dates, but not at the second. The effect was apparent both where urea had been applied, and where it had not, suggesting that at least part of the response to LessN was due to improved release of N from the soil.

Table 4.1 Nitrogen uptake (kg N/ha) in herbage on Day 14 (22 June 2009)

	Urea Rate (kg/ha)			
	0	40	80	Mean (±1.006)
No Less-N	10.3	12.4	14.6	12.4a
With Less-N	10.8	17.3	20.5	16.2b
Mean (±1.232)	10.5	14.8	17.5	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

Table 4.2 Nitrogen uptake (kg N/ha) in herbage on Day 30 (8 July 2009)

	Urea Rate (kg/ha)			
	0	40	80	Mean (±1.503)
No Less-N	22.2	25.5	37.5	28.4a
With Less-N	23.0	32.2	40.4	31.9a
Mean (±1.840)	22.6	28.8	38.9	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

Table 4.3 Nitrogen uptake (kg N/ha) in herbage on Day 42 (20 July 2009)

	Urea Rate (kg/ha)			
	0	40	80	Mean (±2.904)
No Less-N	36.2	47.7	61.8	48.6a
With Less-N	48.5	53.2	74.6	58.8b
Mean (±3.556)	42.3	50.4	68.2	

a,b: Different letters indicate statistical difference with LessN treatment ($p<0.05$)

Discussion:

The sampling programme has shown that both DM yield and N uptake were positively influenced by urea application. On the first sampling occasion, two weeks after treatment application, the DM response was very small (or non existent) but treatment effects were apparent in terms of N uptake because crops receiving urea had a higher N concentration. On later sampling occasions, the effects on DM production were clearly visible.

Throughout the experiment, the effect of LessN was positive, increasing N uptake and DM yield.

Appendix 1

Analysis of N and additives effects
P meter

Analysis of Variance for p22.6.09, AD P=0.369

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	471876	471876	235938	28.37	0.000
add	1	4154	4154	4154	0.50	0.488
N*add	2	10563	10563	5281	0.64	0.540
block	4	123313	123313	30828	3.71	0.021
Error	20	166336	166336	8317		
Total	29	776241				

S = 91.1964 R-Sq = 78.57% R-Sq(adj) = 68.93%

ANOVA table for date for measurement made.
AD – is Anderson Darling test of normality for residuals (must be >0.05)- all are.
My comment on which treatments are different using Tukey's test where necessary.

N1 different to 2 and 3

Analysis of Variance for p8.7.09, AD P=0.230

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	2624689	2624689	1312345	24.12	0.000
add	1	124679	124679	124679	2.29	0.146
N*add	2	22304	22304	11152	0.20	0.816
block	4	145957	145957	36489	0.67	0.620
Error	20	1088285	1088285	54414		
Total	29	4005915				

S = 233.269 R-Sq = 72.83% R-Sq(adj) = 60.61%

All N rates different to each other

Analysis of Variance for p20.7.09, AD P=0.843

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	6079417	6079417	3039708	50.99	0.000
add	1	201720	201720	201720	3.38	0.081
N*add	2	157827	157827	78914	1.32	0.288
block	4	163910	163910	40977	0.69	0.609
Error	20	1192223	1192223	59611		
Total	29	7795097				

S = 244.154 R-Sq = 84.71% R-Sq(adj) = 77.82%

All N rates different to each other

Appendix 2

Clipping

Analysis of Variance for c22.6.09, AD P=0.725

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	16695	16695	8348	0.16	0.855
add	1	243721	243721	243721	4.60	0.044
N*add	2	24849	24849	12425	0.23	0.793
block	4	124126	124126	31031	0.59	0.677
Error	20	1060079	1060079	53004		
Total	29	1469470				

S = 230.226 R-Sq = 27.86% R-Sq(adj) = 0.00%

Additives different

Analysis of Variance for c8.7.09, AD P=0.648

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	2356078	2356078	1178039	13.91	0.000
add	1	65707	65707	65707	0.78	0.389
N*add	2	127421	127421	63710	0.75	0.484
block	4	511305	511305	127826	1.51	0.237
Error	20	1693591	1693591	84680		
Total	29	4754102				

S = 290.998 R-Sq = 64.38% R-Sq(adj) = 48.35%

N1 and N2 different to N3

Analysis of Variance for c20.7.09, AD P=0.616

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	8122894	8122894	4061447	9.23	0.001
add	1	1966080	1966080	1966080	4.47	0.047
N*add	2	388310	388310	194155	0.44	0.649
block	4	489374	489374	122343	0.28	0.889
Error	20	8798108	8798108	439905		
Total	29	19764766				

S = 663.254 R-Sq = 55.49% R-Sq(adj) = 35.45%

N1 and N2 different to N3
Additives different

Appendix 3

%N in herbage

Analysis of Variance for N22.6.09, AD P=0.189

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	5.75738	5.75738	2.87869	41.06	0.000
add	1	0.00108	0.00108	0.00108	0.02	0.902
N*add	2	0.04394	0.04394	0.02197	0.31	0.735
block	4	0.58545	0.58545	0.14636	2.09	0.120
Error	20	1.40223	1.40223	0.07011		
Total	29	7.79008				

S = 0.264786 R-Sq = 82.00% R-Sq(adj) = 73.90%

All N rates different to each other

Analysis of Variance for N8.7.09, AD P=0.334

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	0.21762	0.21762	0.10881	3.89	0.037
add	1	0.07301	0.07301	0.07301	2.61	0.122
N*add	2	0.02409	0.02409	0.01204	0.43	0.656
block	4	0.02285	0.02285	0.00571	0.20	0.933
Error	20	0.55891	0.55891	0.02795		
Total	29	0.89648				

S = 0.167170 R-Sq = 37.65% R-Sq(adj) = 9.60%

N 1 just different to N3

Analysis of Variance for N20.7.09, AD P=0.242

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	0.18582	0.18582	0.09291	5.82	0.010
add	1	0.02465	0.02465	0.02465	1.54	0.228
N*add	2	0.01069	0.01069	0.00534	0.33	0.719
block	4	0.03557	0.03557	0.00889	0.56	0.696
Error	20	0.31927	0.31927	0.01596		
Total	29	0.57600				

S = 0.126347 R-Sq = 44.57% R-Sq(adj) = 19.63%

N1 different to N3

Appendix 4

N recovery in herbage

Analysis of Variance for NR22.6.09, AD P=0.105

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	251.59	251.59	125.80	8.29	0.002
add	1	107.07	107.07	107.07	7.05	0.015
N*add	2	40.53	40.53	20.27	1.33	0.286
block	4	106.47	106.47	26.62	1.75	0.178
Error	20	303.64	303.64	15.18		
Total	29	809.30				

S = 3.89641 R-Sq = 62.48% R-Sq(adj) = 45.60%

N1 different to N3
Additives different

Analysis of Variance for NR8.7.09, AD P=0.524

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	1352.37	1352.37	676.18	19.96	0.000
add	1	89.36	89.36	89.36	2.64	0.120
N*add	2	44.84	44.84	22.42	0.66	0.527
block	4	141.67	141.67	35.42	1.05	0.409
Error	20	677.44	677.44	33.87		
Total	29	2305.68				

S = 5.81995 R-Sq = 70.62% R-Sq(adj) = 57.40%

N1 and N2 different to N3

Analysis of Variance for NR20.7.09, AD P=0.884

Source	DF	Seq SS	Adj SS	Adj MS	F	P
N	2	3494.2	3494.2	1747.1	13.81	0.000
add	1	778.5	778.5	778.5	6.16	0.022
N*add	2	86.1	86.1	43.1	0.34	0.716
block	4	160.5	160.5	40.1	0.32	0.863
Error	20	2529.7	2529.7	126.5		
Total	29	7049.1				

S = 11.2466 R-Sq = 64.11% R-Sq(adj) = 47.96%

N1 and N2 different to N3
Additives different