Meta-Analysis of LessN Trials

Dr David Baird, VSN NZ

Meta-Analysis of All LessN NZ Pasture trials

Dr David Baird VSN NZ (David@vsn.co.nz) 4 April 2013

Analysis performed for 1) all trials (including some that did not have a U40 or S40 treatment), and then a range of selection of trials being 2) N Responsive trials only, 3) Independent N responsive, 4) Independent N Responsive less below soil temperature trials and 5) the latter without the Reporoa trial which had high rainfall and flooding just prior to application.

All Trials Analysis 63 Trials	**Mean**	**LowCI95%**	**HighCI95%**	**LSD**
Absolute Difference (LessN40-N40) (kg/ha)	239	216	263	23
LessN40:N40 Response Ratio	2.47	2.19	2.76	
LessN40:N80 Response Ratio	0.96	0.90	1.02	
LessN40:S40 Response Ratio	1.77	1.43	2.11	
LessN40:S80 Response Ratio	1.04	0.92	1.16	

All 59 N-Responsive Trials	**Mean**	**LowCI95%**	**HighCI95%**	**LSD**
Absolute Difference (LessN40-N40) (kg/ha)	252	228	276	24
LessN40:N40 Response Ratio	2.50	2.22	2.79	
LessN40:N80 Response Ratio	0.97	0.92	1.03	
LessN40:S40 Response Ratio	1.83	1.45	2.20	
LessN40:S80 Response Ratio	1.01	0.89	1.13	

All 21 N-Responsive Independent Trials	**Mean**	**LowCI95%**	**HighCI95%**	**LSD**
Absolute Difference (LessN40-N40) (kg/ha)	179	122.77	235	56
LessN40:N40 Response Ratio	1.71	1.39	2.04	
LessN40:N80 Response Ratio	0.92	0.76	1.08	
LessN40:S40 Response Ratio	1.57	1.25	1.88	
LessN40:S80 Response Ratio	0.95	0.82	1.08	

All 18 Independent N-Responsive Trials without low soil temperature trials	**Mean**	**LowCI95%**	**HighCI95%**	**LSD**
Absolute Difference (LessN40-N40) (kg/ha)	189	128.74	249	60
LessN40:N40 Response Ratio	1.75	1.40	2.11	
LessN40:N80 Response Ratio	1.05	0.81	1.29	
LessN40:S40 Response Ratio	1.59	1.27	1.90	
LessN40:S80 Response Ratio	0.96	0.83	1.09	

All 17 Independent N-Responsive Trials without low soil temperature trials nor high rainfall/flooding trial	**Mean**	**LowCI95%**	**HighCI95%**	**LSD**
Absolute Difference (LessN40-N40) (kg/ha)	208	145.69	270	62
LessN40:N40 Response Ratio	1.88	1.46	2.30	
LessN40:N80 Response Ratio	1.06	0.82	1.30	
LessN40:S40 Response Ratio	1.72	1.34	2.09	
LessN40:S80 Response Ratio	1.00	0.85	1.14	

Meta-Analysis of 52 LessN trials (N Responsive)

Dr David Baird VSN NZ (David@vsn.co.nz) 19 October 2012

This report examines a series of 52 trials conducted on the LessN system. The LessN system involves adding 3 litres/ha of LessN solution with 40 kg/ha of urea in 200 litres of water/ha, and applied by spraying. In each trial a control had no application of urea, and a 40N treatment had 40 kg/ha of urea in 200 litres of water/ha applied by spraying. Some of the trials (43) also had a 80N treatment where 80 kg/ha of urea was used. Other treatments where present in some trials, but there results are not reported here. Donaghys ran 38 of the trials, and other independent operators ran 14 trials. The trials were conducted all around New Zealand from 2007 – 2011.

Probe Dry Matter results

Of the 52 trials, 51 had a positive response to 40N (Culverden2 had a reduction in yield for 40 kg N over control), and 3 trials had a reduction in yield in adding 80N over 40N (Canterbury07, LeestonSpreadSpray and SpreadSpray1). In all of the trials, the LessN system gave a positive response over the control, and a significant response at the 5% level in 51 trials (98%). In 50 trials (96%) the LessN system gave a positive response over 40N and in 32 of the trials (62%), this response was significant at the 5% level. The responses to the LessN system over 40N are given in figure 1, which gives the response in dry matter in kg/hectare/day. The percentage responses to the LessN system relative to 40N are given in figure 2. The average response overall over trials estimated from a REML meta-analysis which uses each trials reliability in combining the trials is 16 kg DM/ha/day with a 95% confidence interval of 15-17. In a simpler approach, that simply uses the variation between trials in a standard t-test, then the average response is 10 kg DM/ha/day with a 95% confidence interval of 8.5 - 12 which is significant at the 0.1% level. The average percentage increase of the LessN system over 40N from the meta-analysis is 22% with a 95% confidence interval of 20-24%. Using a simple t-test this average is 29.5% with a 95% confidence interval of 22 – 37%. As the ratios of LessN to 40N do not appear to be normally distributed, by skewed to the right, an analysis of the log-transformed ratios is suggested to resolve this problem, and this gives an average percentage increase of 24% with a 95% confidence interval of 19 – 29%.

Calculating the equivalent effect of the LessN system in terms of kg N added per hectare for the 41 farms that gave a response to 80N over 40N, assuming a linear response between 40 and 80N, we get the histogram shown in figure 3. Note, that of the 3 farms showing no response to 80N, two of these showed a response to LessN. The average addition kg of N over 40 kg required to give the same response as LessN is 39 kg with a 95% confidence interval of (35 – 44) kg.

Figure 4 shows the response of the LessN system (LessN – control) relative to that of 40N (40N – control) for each farm. This was not calculated for the Culverden2 farm where 40N yield less than the control. The average relative response from a meta-analysis was 2.64 with a 95% confidence interval of (2.34 – 2.94).

Comparing the LessN system vs. 80N in the 44 trials that had both in them, gives a difference of -0.6 kg DM/ha/day in favour of 80N with a 95% confidence interval of -2 – 0. The LessN system gives a greater yield in 22 trials and a smaller yield in 22 trials, with only 1 of these trials showing a significant difference advantage to the 80N treatment (no more significant results than expected, given 44 tests at the 0.05 significance level). The results for the individual trials is shown in figure 5, and the histogram of the differences in figure 6. A simple t-test on the results (ignoring the different variability of the trials) gives a non-significant result, with a mean difference of -0.2 kg DM/ha/day and a 95% confidence interval of -1.3 - 0.9 and a two sided p value of 0.69. I would conclude that on average there was less than a 3% difference between the two treatments, and so that they are equivalent to each other if a difference of less that 3% is not important within the farming system.

Probe DM Independent Trials only

If the trials are restricted to the 14 independent trials, the results are shown below in figures 7-9. The difference between the LessN system and 40N is now averages 7.1 kg DM/ha/day with 95% confidence interval of 4.9-9.3. The average percentage increase of the LessN system relative to 40N is 13% with 95% confidence interval of 9 – 17%. The average relative response of the LessN system relative to 40N is 1.7 with a 95% confidence interval of 1.4 – 2.0.

Mown DM Results

21 of the trials were mown, and the mowing results are shown below in figures 10 and 11. The difference between LessN and 40 kg N is now averages 4.6 kg DM/ha/day with 95% confidence interval of 2.4-6.8. The average percentage increase of LessN relative to 40kg N is 7.5% with 95% confidence interval of 3.8 – 11.2%. The average relative response of LessN relative to 40 kg N is 1.5 with a 95% confidence interval of 1.2 – 1.8.

Figure 1. The response measured by probe of the LessN system over 40N by farm with 95% confidence intervals. The green point is the overall meta-analysis result.

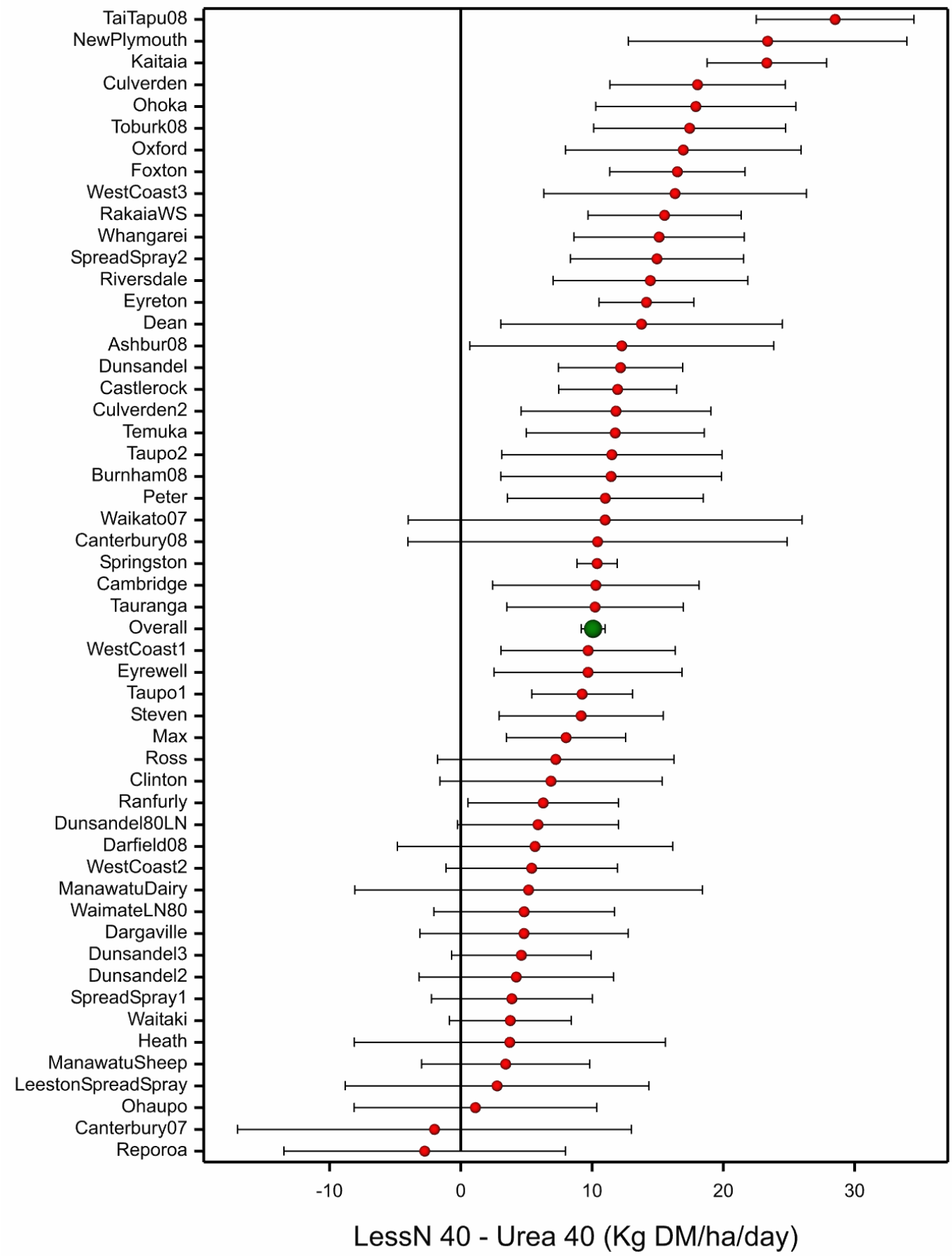
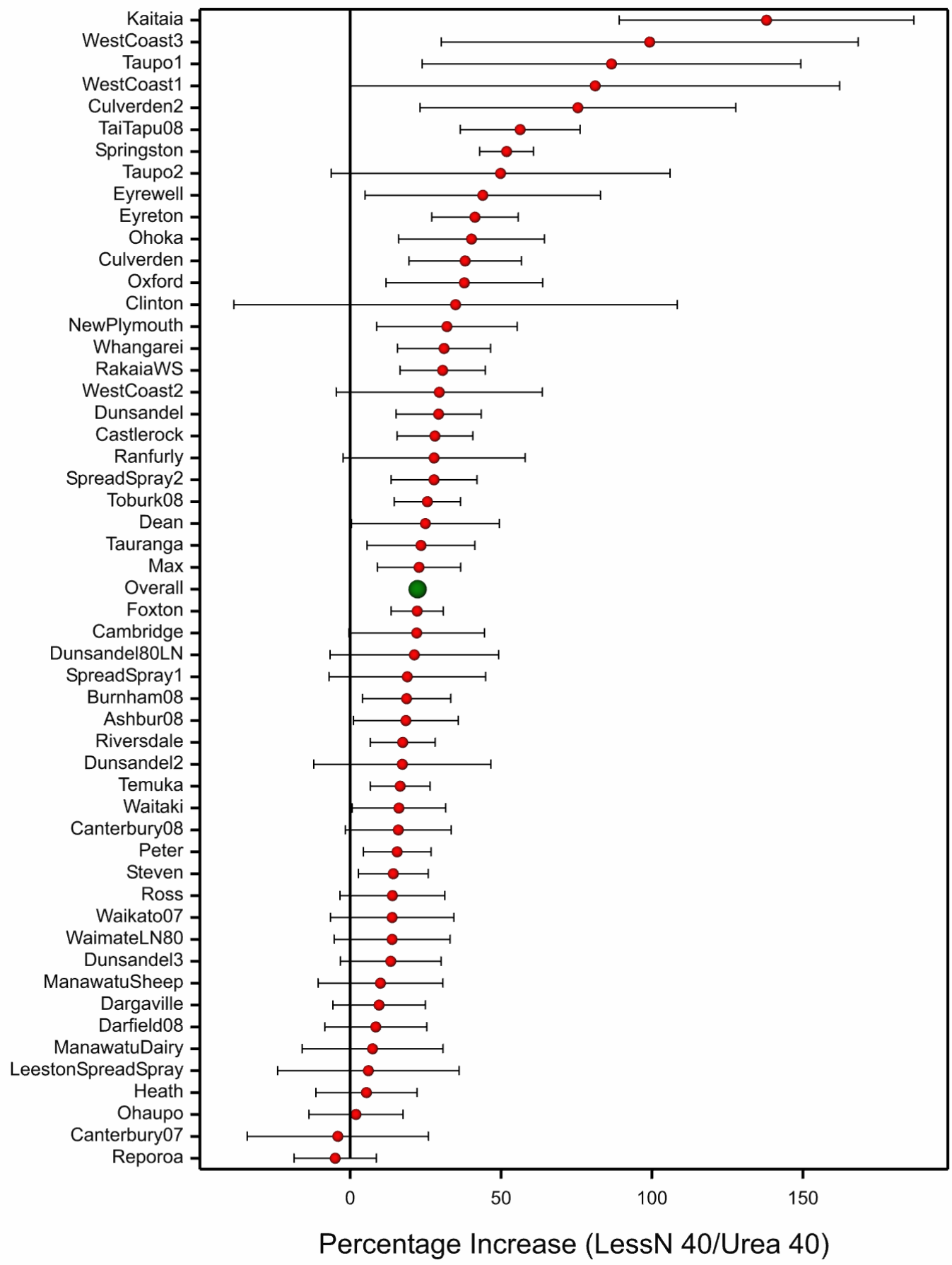


Figure 2. The percentage response by measured by probe of the LessN system over 40N by farm with 95% confidence intervals. The green point is the overall meta-analysis result.



Note the overall confidence interval is obscured by the dot.

Figure 3. The histogram of the equivalent extra liquid urea required to get the same response as the LessN system in the 41 farms showing a response to 80N over 40N.

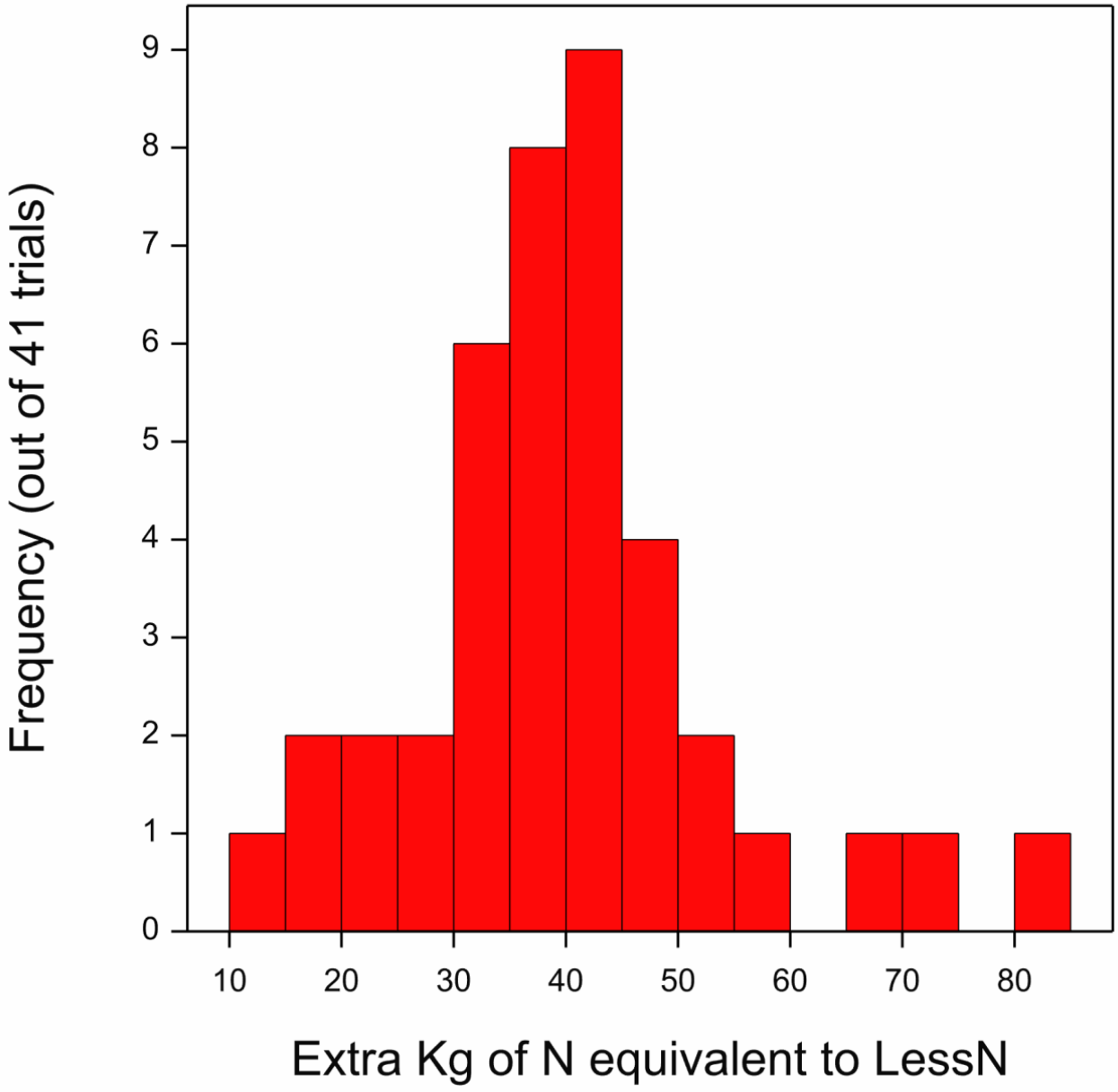


Figure 4. The relative response by measured by probe of the LessN system to 40N over control (LessN – control)/(40N – control) with 95% confidence interval by Farm.

Note: This was not calculated for farms that did not respond to 40 kg N.

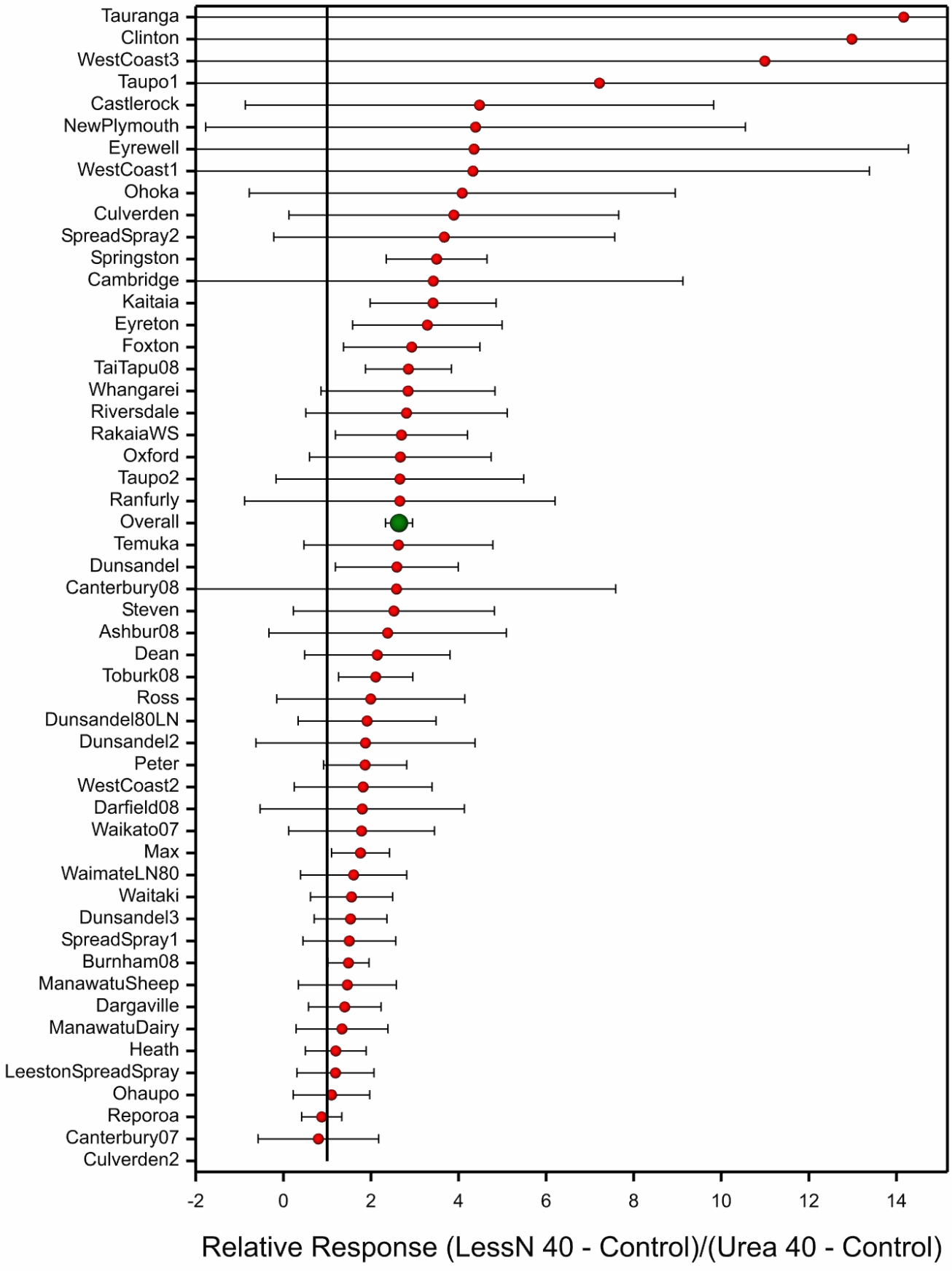


Figure 5. The response measured by probe of the LessN system over 80N by farm with 95% confidence intervals. The green point is the overall meta-analysis result.

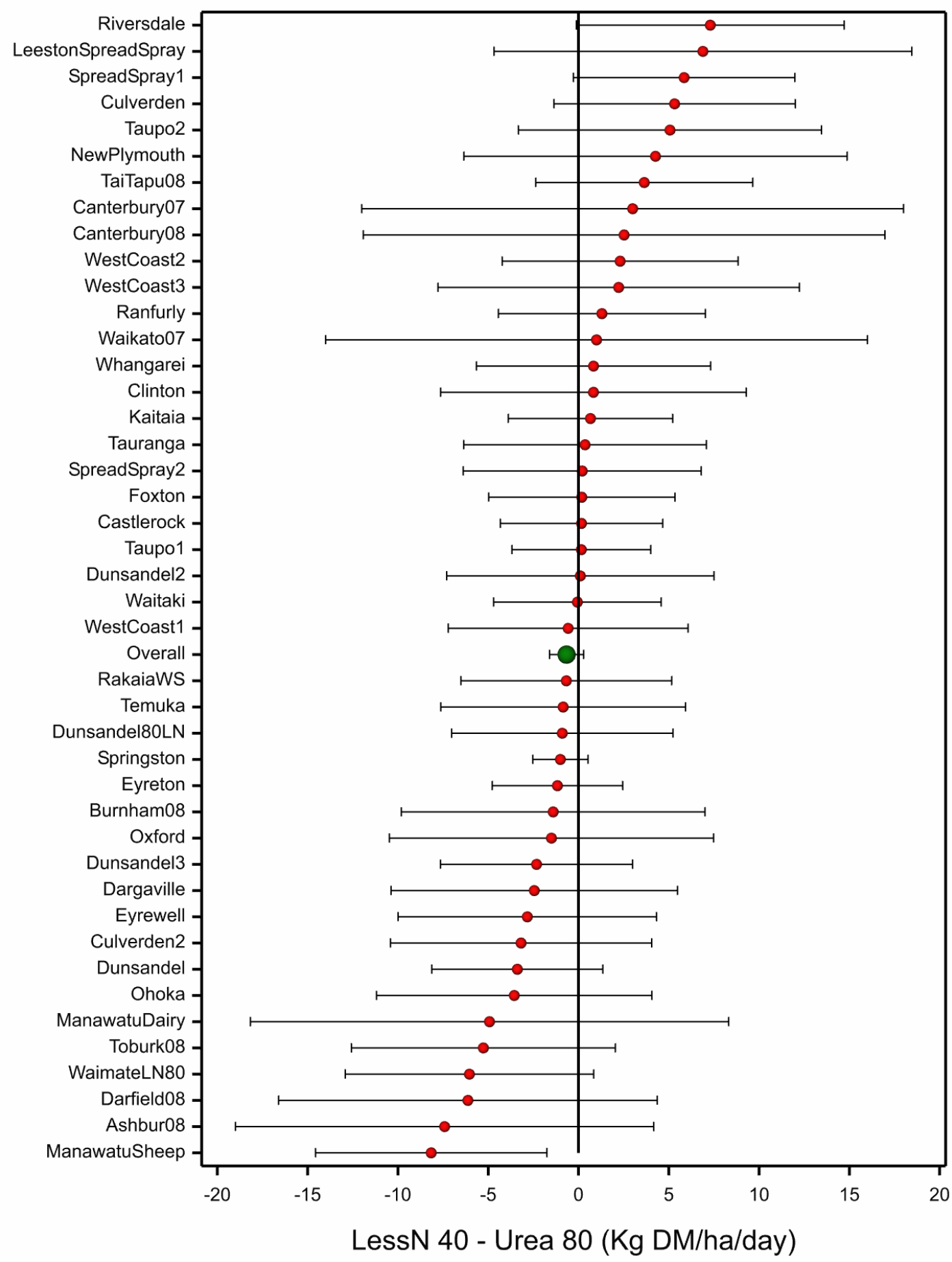
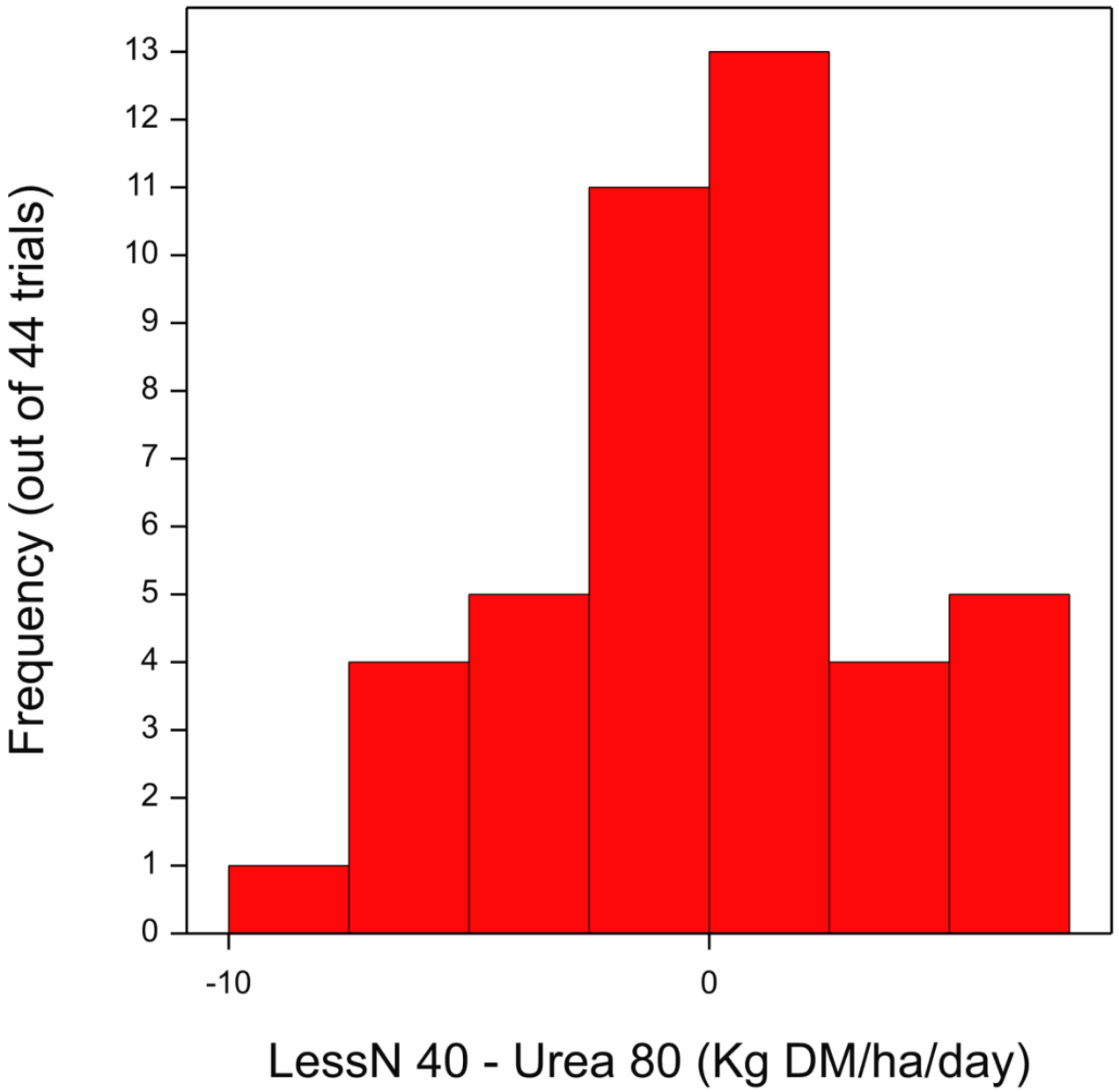


Figure 6. The histogram of the difference in yield between the LessN system and 80N in the 44 farms having the 80N treatment.



Probe DM Independent Trials only

Figure 7: The response measured by probe of the LessN system over 40N by farm for independent trials only, with 95% confidence intervals.

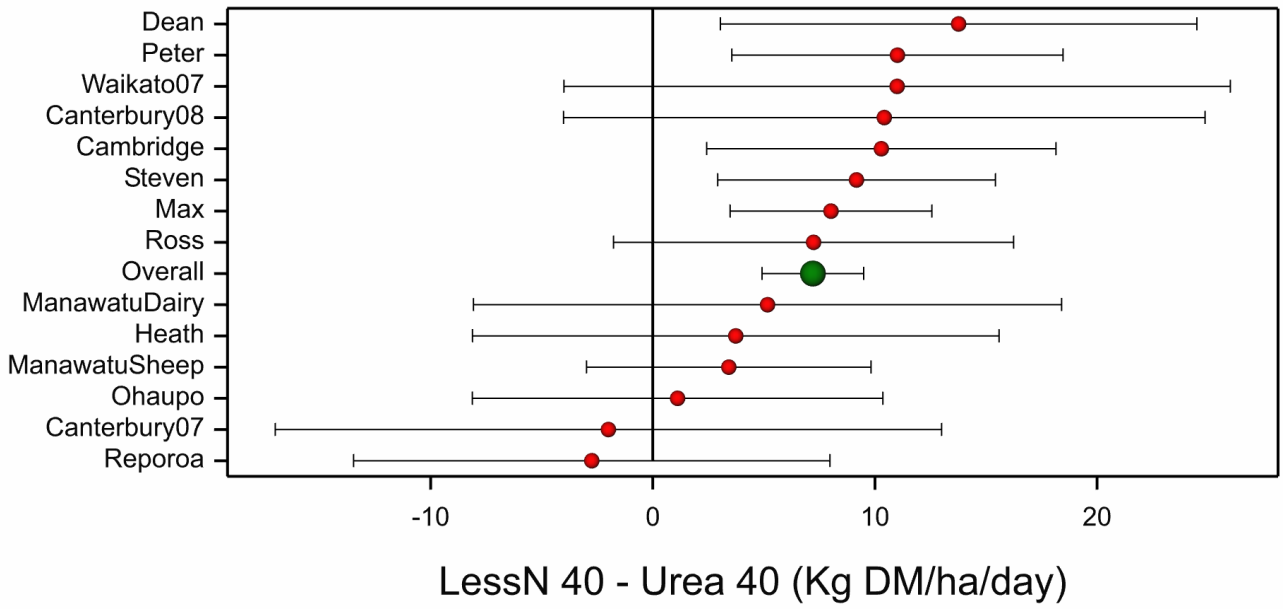


Figure 8. The percentage response by measured by probe of The LessN system over 40N by farm for independent trials only, with 95% confidence interval.

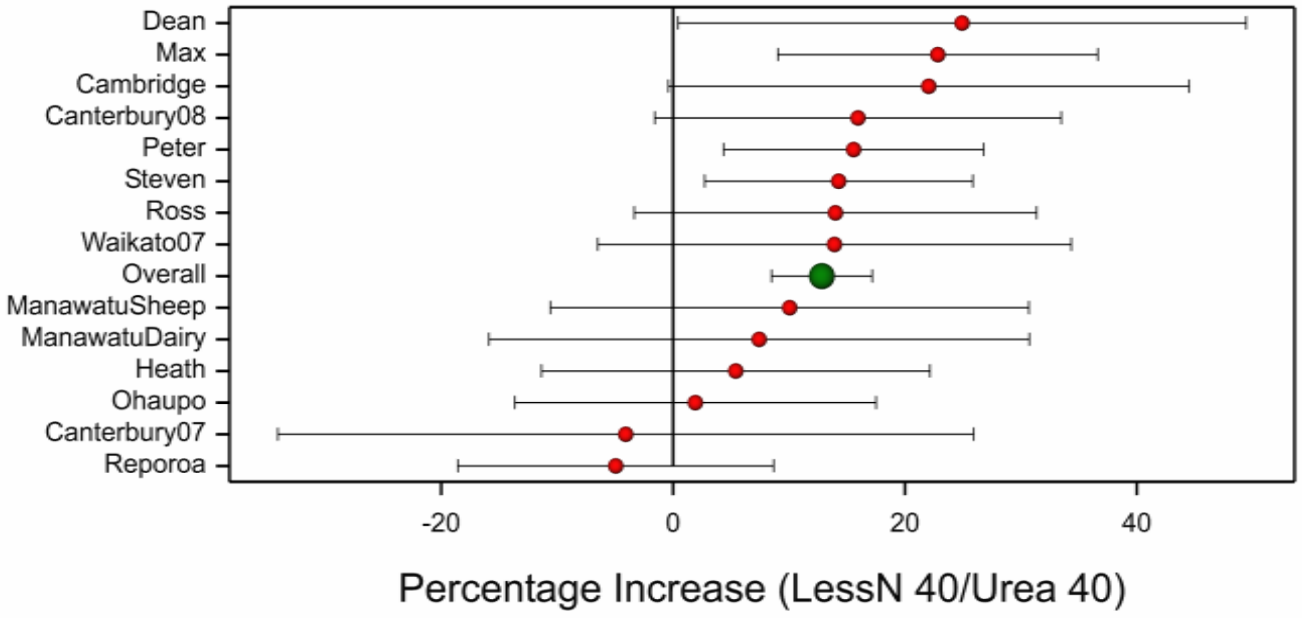
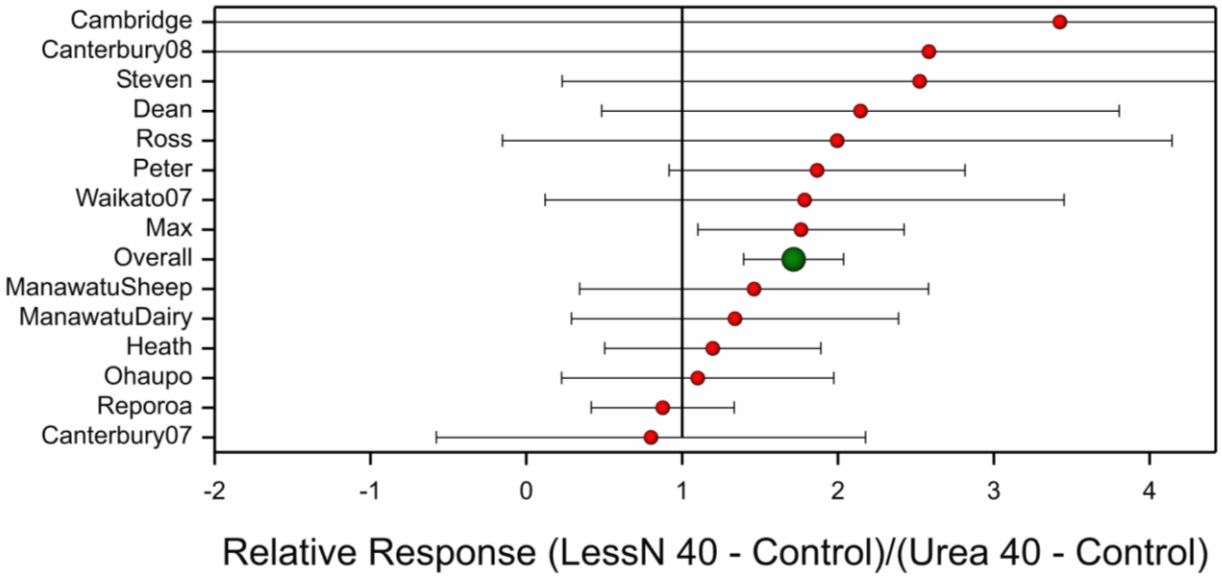
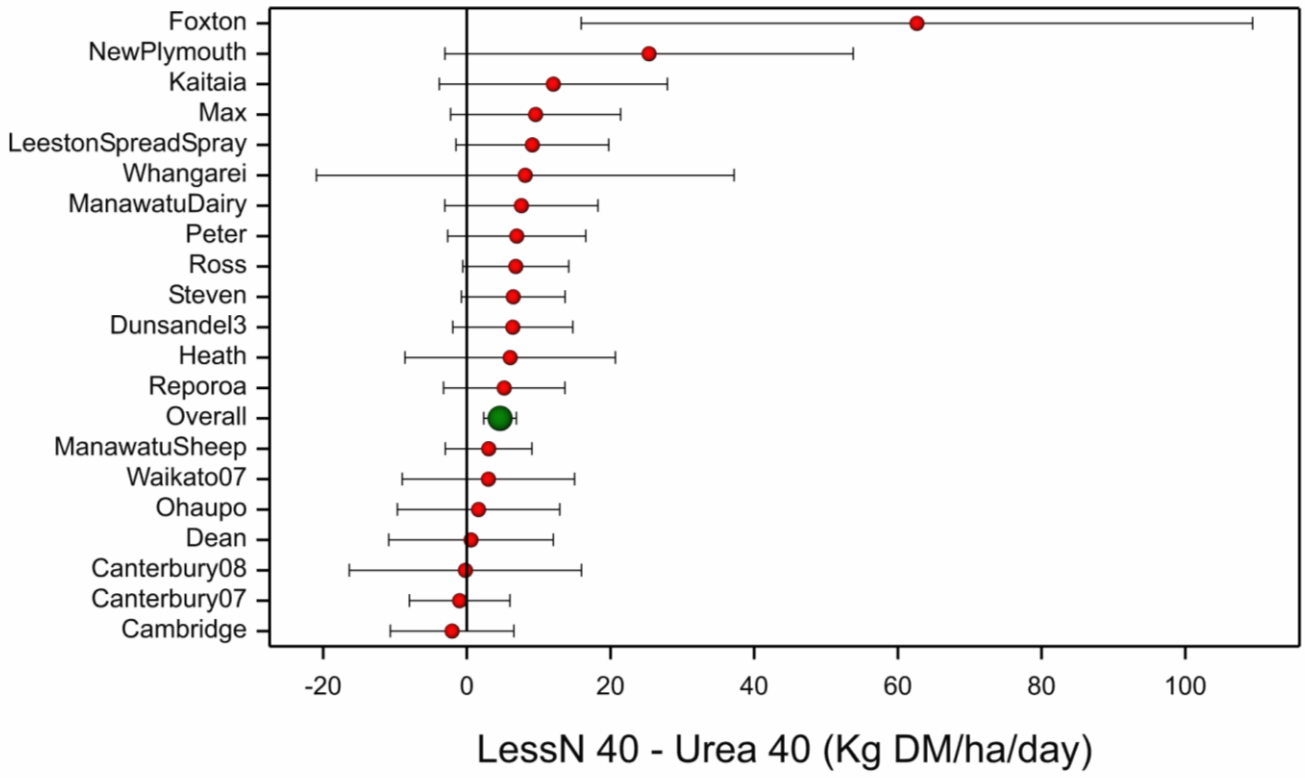


Figure 9. The relative response of the LessN system to 40N over control (LessN – control)/(40N – control) by farm for independent trials only, with 95% confidence intervals.



Mown DM Results

Figure 10. The response measured by mowing of the LessN system over 40N by farm, with 95% confidence intervals.



Meta-Analysis of a subset of independent LessN trials

Dr David Baird VSN NZ (David@vsn.co.nz) **7 February 2013**

Analysis of probe dry matter in independent trials without Canterbury 07 and Manawatu Dairy & Sheep trials

The exclusion of the Canterbury 07 and Manawatu trials is based on these having low soil temperatures. If these figures are used, then the recommendation for LessN should include a proviso that it not be used at low soil temperatures.

If the trials are restricted to the 11 independent trials, the results are shown below in figures 1-5. The difference between the LessN system and 40N averages 8 kg DM/ha/day with 95% confidence interval of 5.5 - 10.5 and a standard error of +/-1.2 . The difference is significant at the 0.1% level as measured by either a REML meta-analysis or a simple t-test. The average percentage increase of the LessN system relative to 40N is 14% with 95% confidence interval of 9.3 – 18.6%. The average relative response of the LessN system relative to 40N is 1.8 with a 95% confidence interval of 1.4 – 2. The difference between LessN and 80N is 6.9 kg DM/ha/day and this is significant at the 0.1% level using a meta-analysis and at the 2.5% level using a t-test.

Figure 1. The response measured by probe of the LessN system over 40N by farm with 95% confidence intervals. The green point is the overall meta-analysis result.

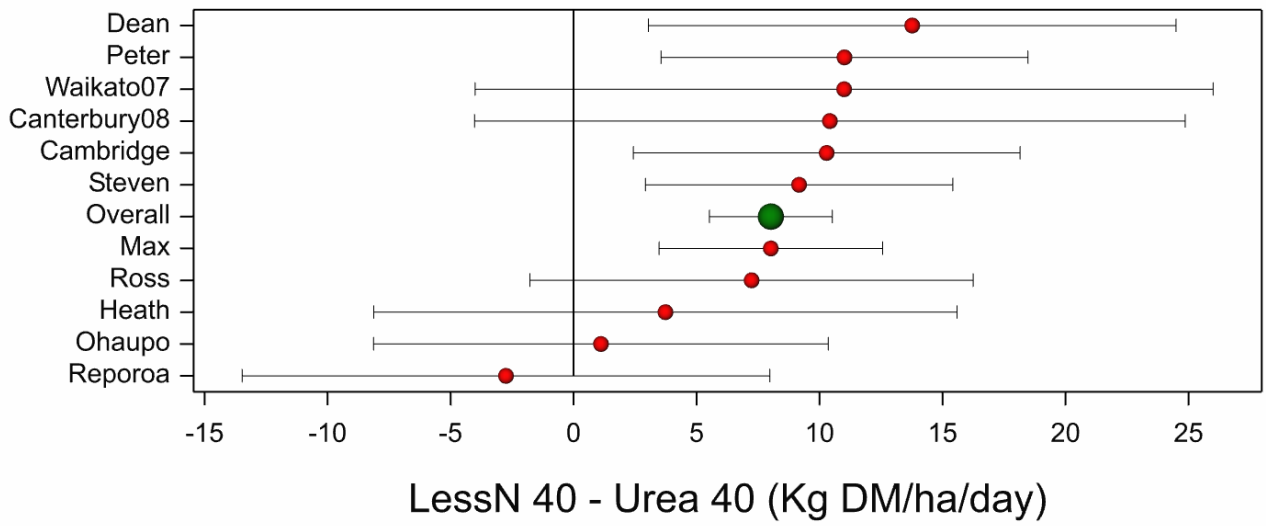


Figure 2. The percentage response by measured by probe of the LessN system over 40N by farm with 95% confidence intervals. The green point is the overall meta-analysis result.

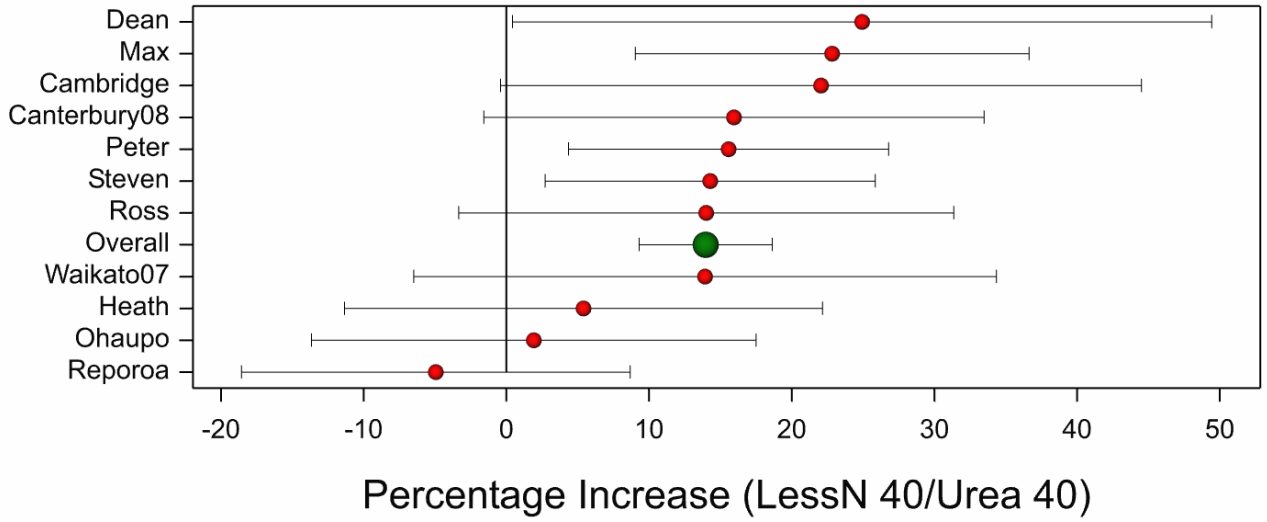


Figure 3. The relative response by measured by probe of the LessN system to 40N over control (LessN – control)/(40N – control) with 95% confidence interval by farm.

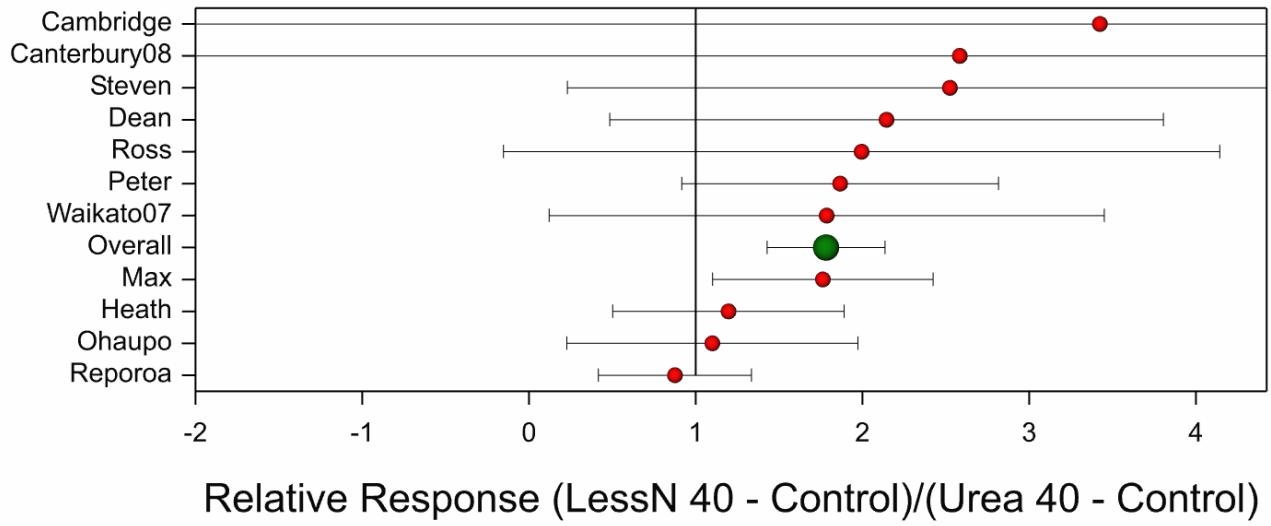


Figure 4. The response measured by probe of the LessN system over 80N by farm with 95% confidence intervals. The green point is the overall meta-analysis result.

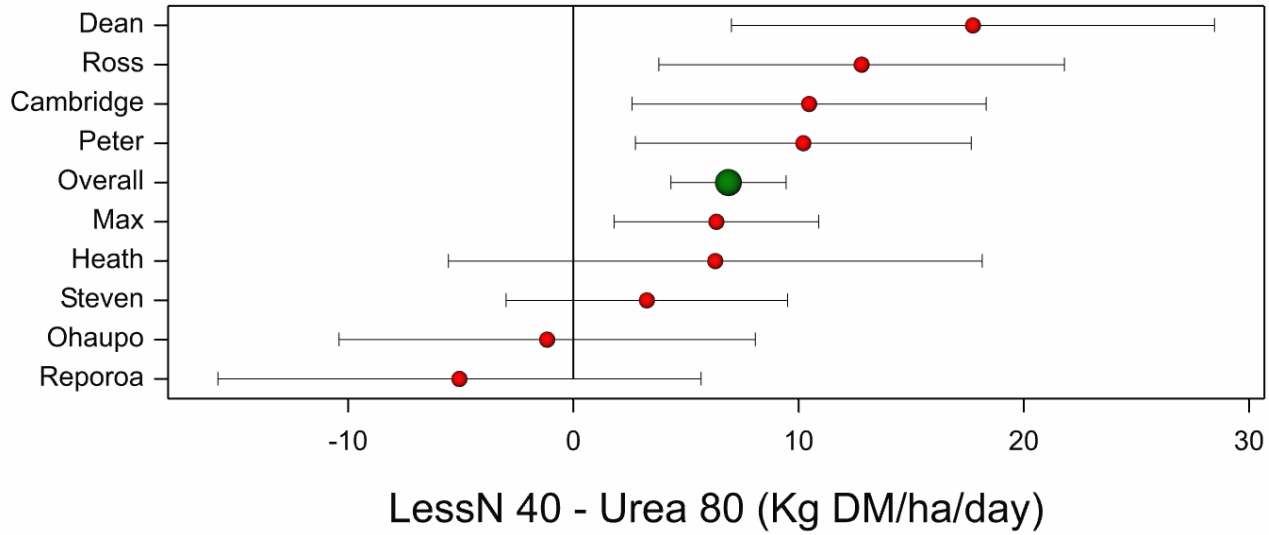
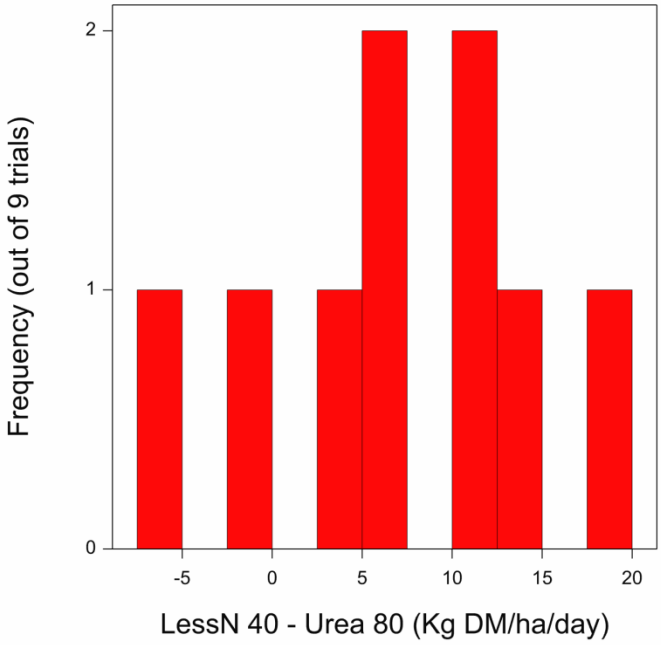


Figure 5. The histogram of the difference in yield between the LessN system and 80N in the 9 farms having the 80N treatment.



Analysis of Independent trials without Canterbury 07, Manawatu Dairy & Sheep and Reporoa trials.

The exclusion of the Canterbury 07, Reporoa & Manawatu and trials is based on these having low soil temperatures or high levels of rainfall. If these figures are used, then the recommendation for LessN should include a proviso that it not be used at low soil temperatures or after heavy rain.

If the trials are restricted to the 10 independent trials, the results are shown below in figures 6-10. The difference between the LessN system and 40N averages 8.5 kg DM/ha/day with 95% confidence interval of 6 – 11.1 and a standard error of +/-1.2 . The difference is significant at the 0.1% level as measured by either a REML meta-analysis or a simple t-test. The average percentage increase of the LessN system relative to 40N is 15% with 95% confidence interval of 10 – 19.5%. The average relative response of the LessN system relative to 40N is 1.9 with a 95% confidence interval of 1.5 – 2.3. The difference between LessN and 80N is 7.5 kg DM/ha/day and this is significant at the 0.1% level using a meta-analysis and at the 1% level using a t-test.

Figure 6. The response measured by probe of the LessN system over 40N by farm with 95% confidence intervals. The green point is the overall meta-analysis result.

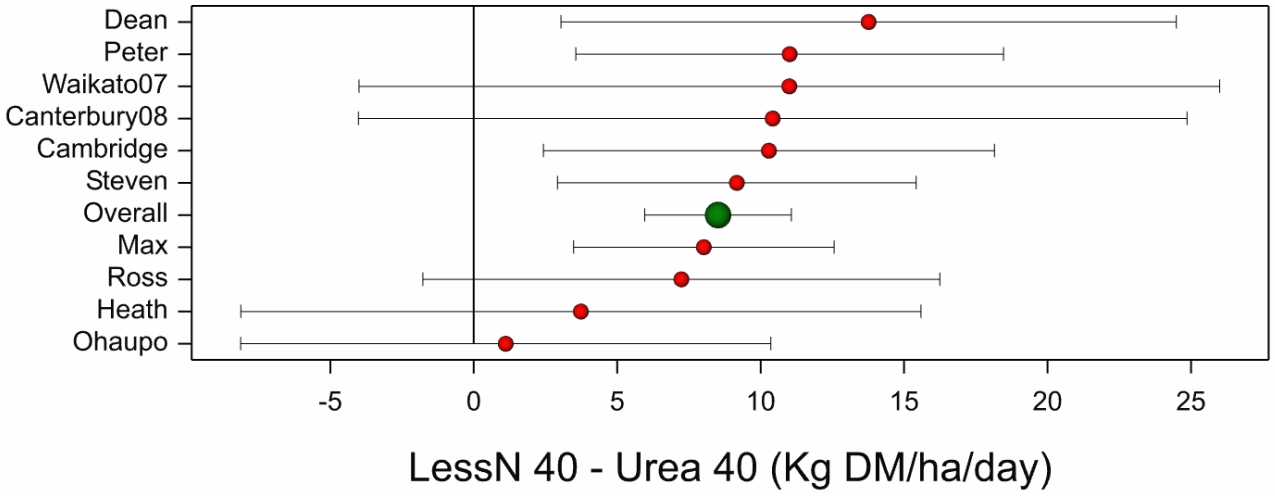


Figure 7. The percentage response by measured by probe of the LessN system over 40N by farm with 95% confidence intervals. The green point is the overall meta-analysis result.

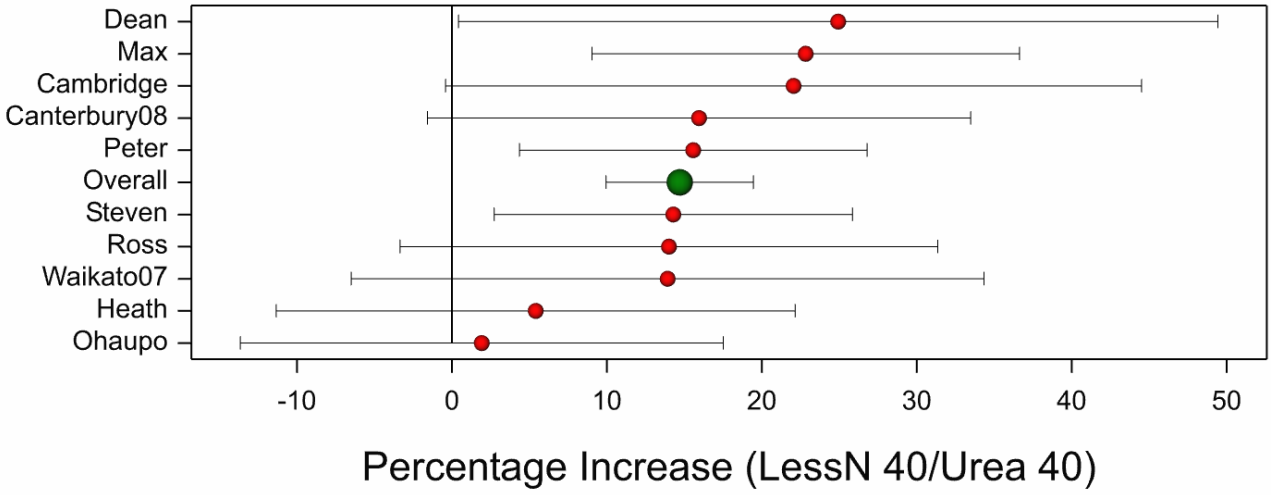


Figure 8. The relative response by measured by probe of the LessN system to 40N over control (LessN – control)/(40N – control) with 95% confidence interval by farm.

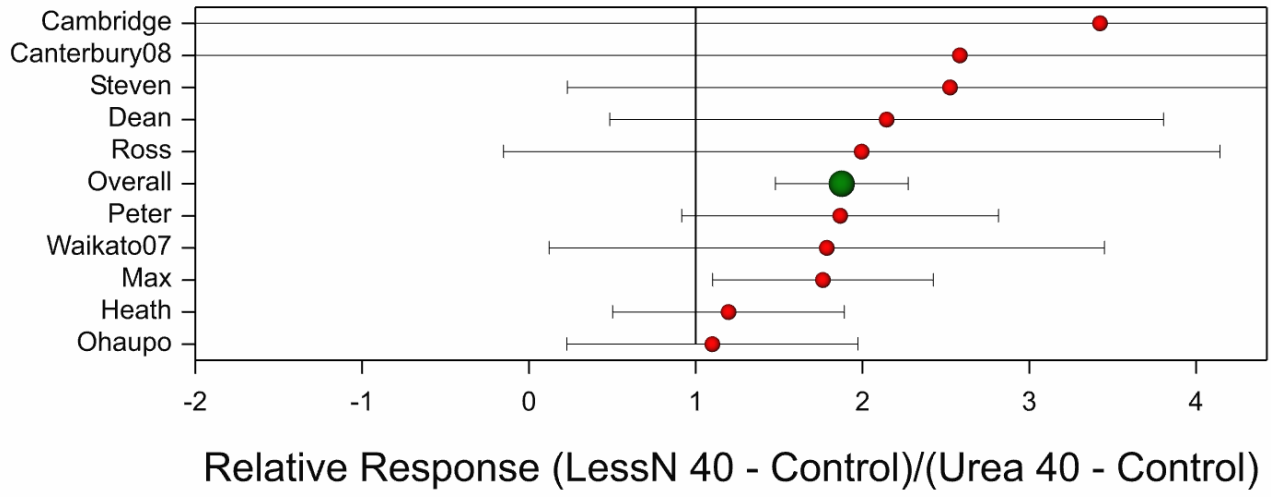


Figure 9. The response measured by probe of the LessN system over 80N by farm with 95% confidence intervals. The green point is the overall meta-analysis result.

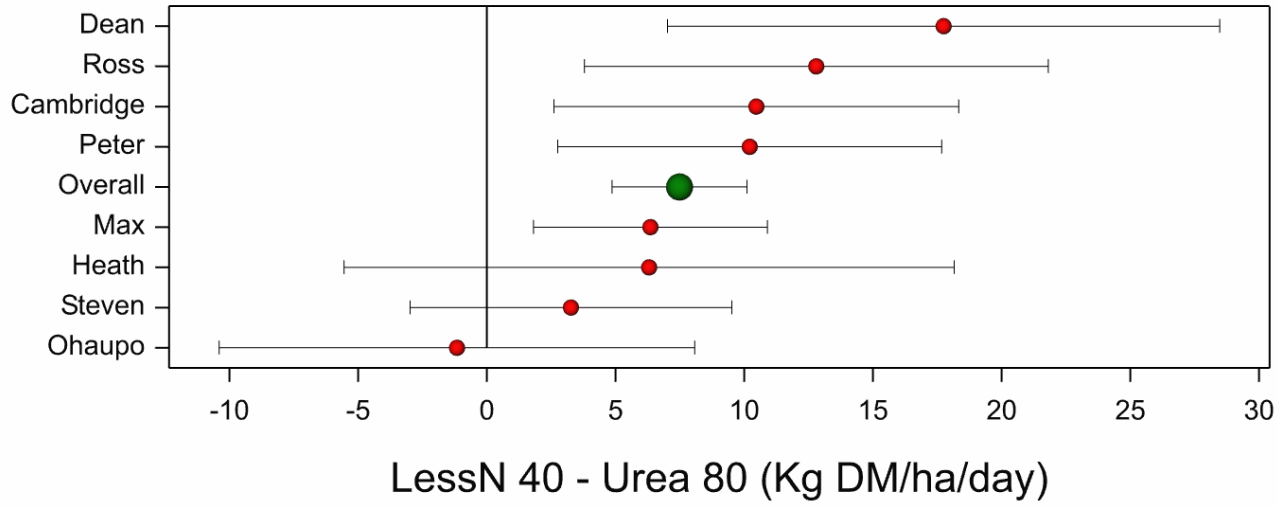
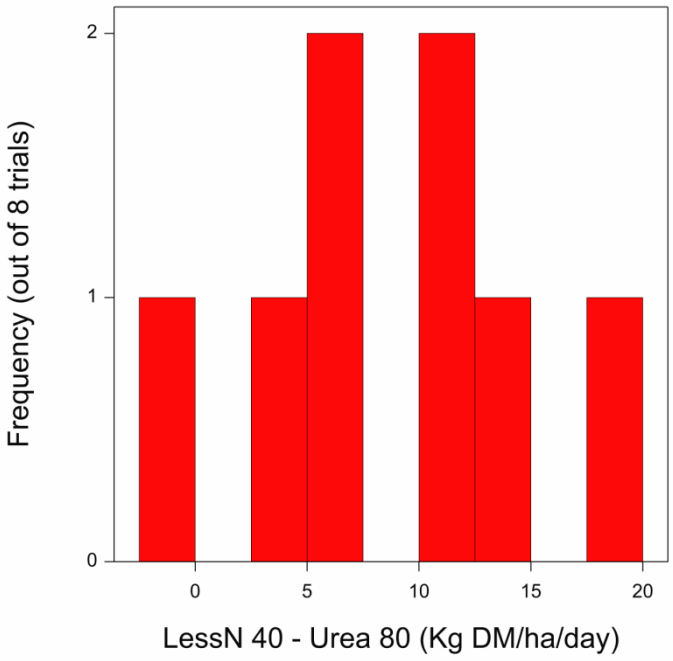


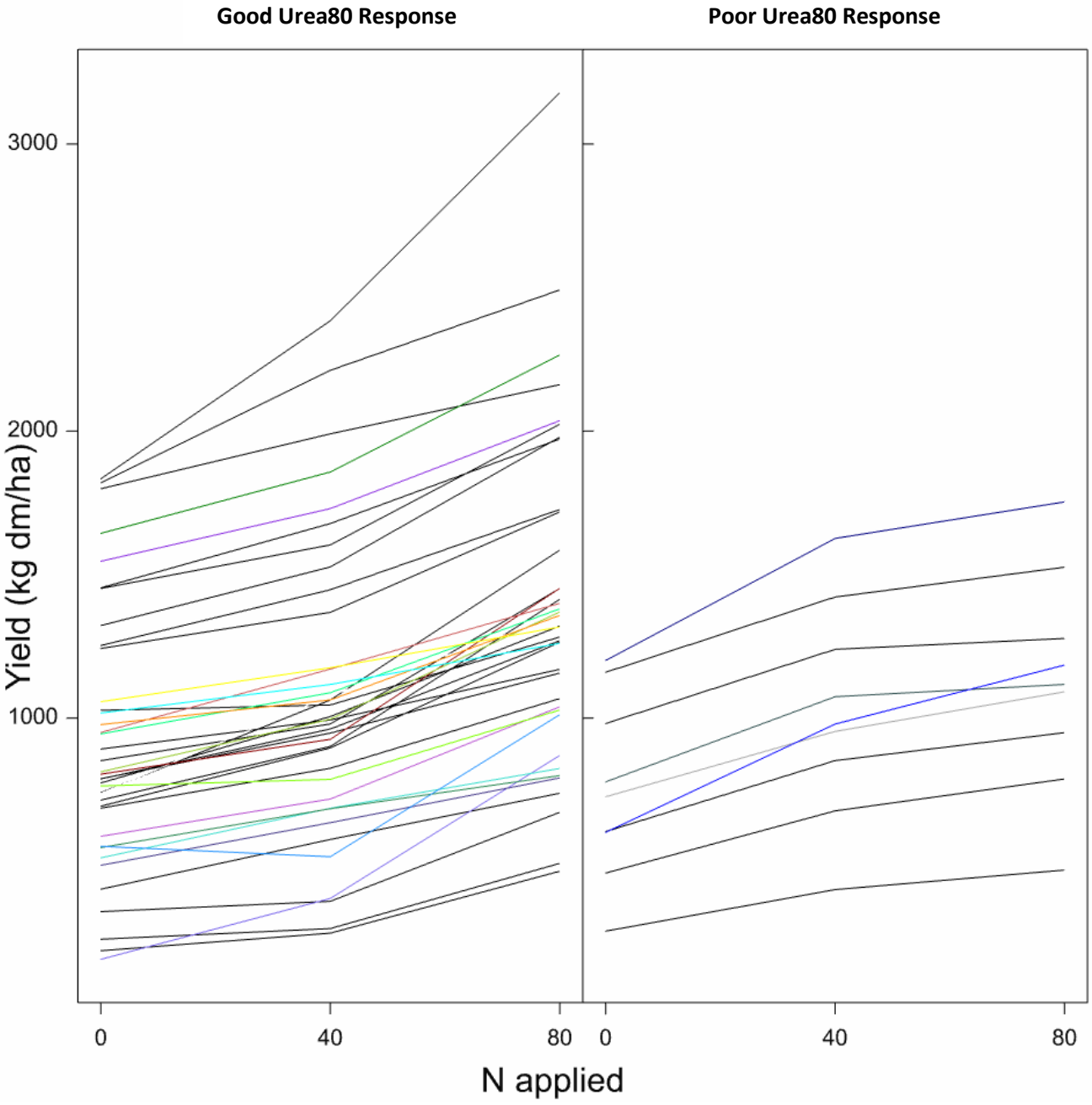
Figure 10. The histogram of the difference in yield between the LessN system and 80N in the 8 farms having the 80N treatment.


Frequency (out of 8 trials)
2
1
0
0
5
10
15
20
LessN 40 - Urea 80 (Kg DM/ha/day)

Meta-Analysis Split by Urea80:Urea40 response level

Dr David Baird VSN NZ (David@vsn.co.nz) 4 April 2013

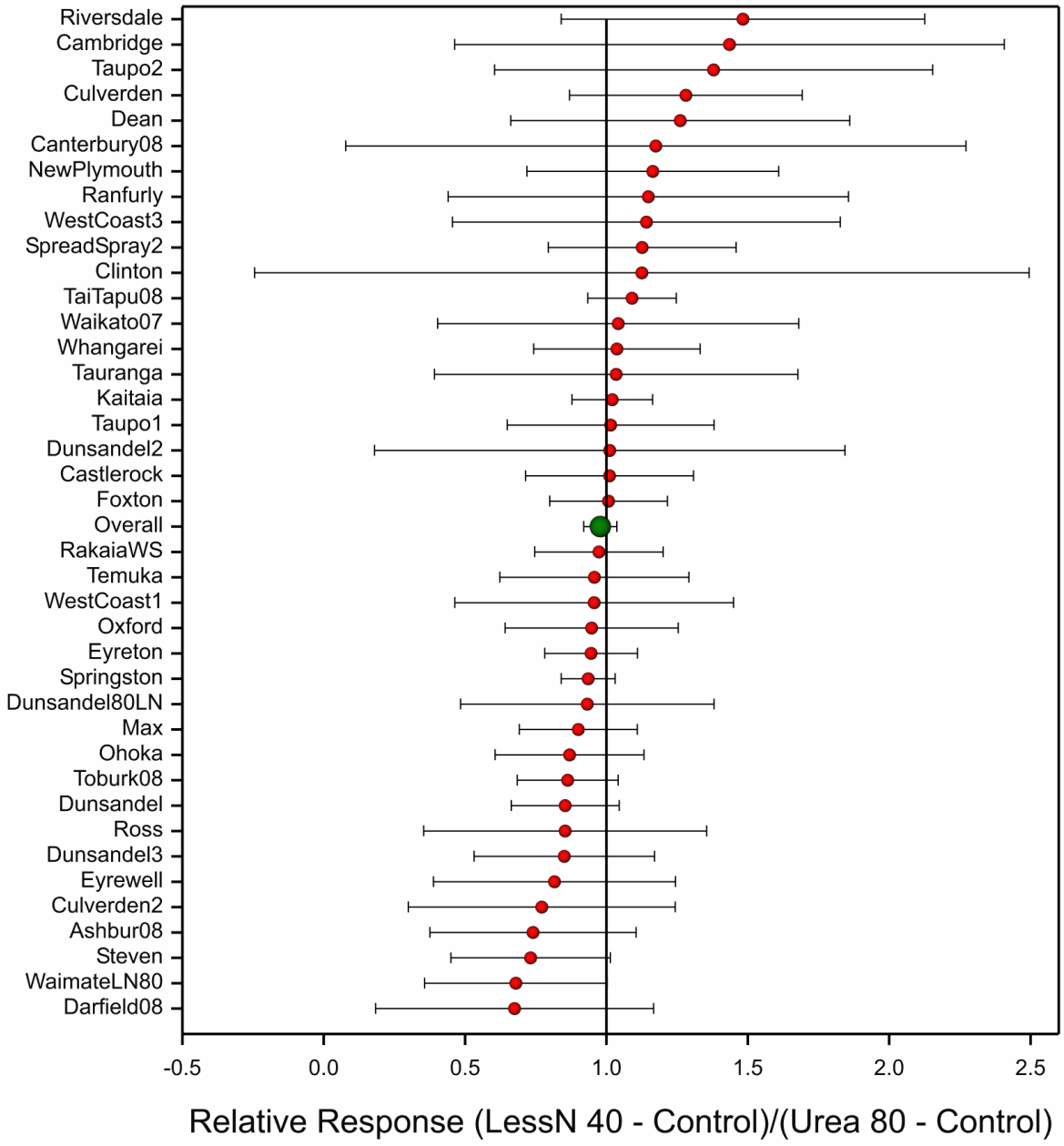
Most N-Responsive Trials had a (Urea80 – Control):(Urea40 – Control) response ratio >1.75 termed "good Urea80 response". These analyses exclude the three low soil temperature trials and the Reporoa high rainfall/flooding trial.

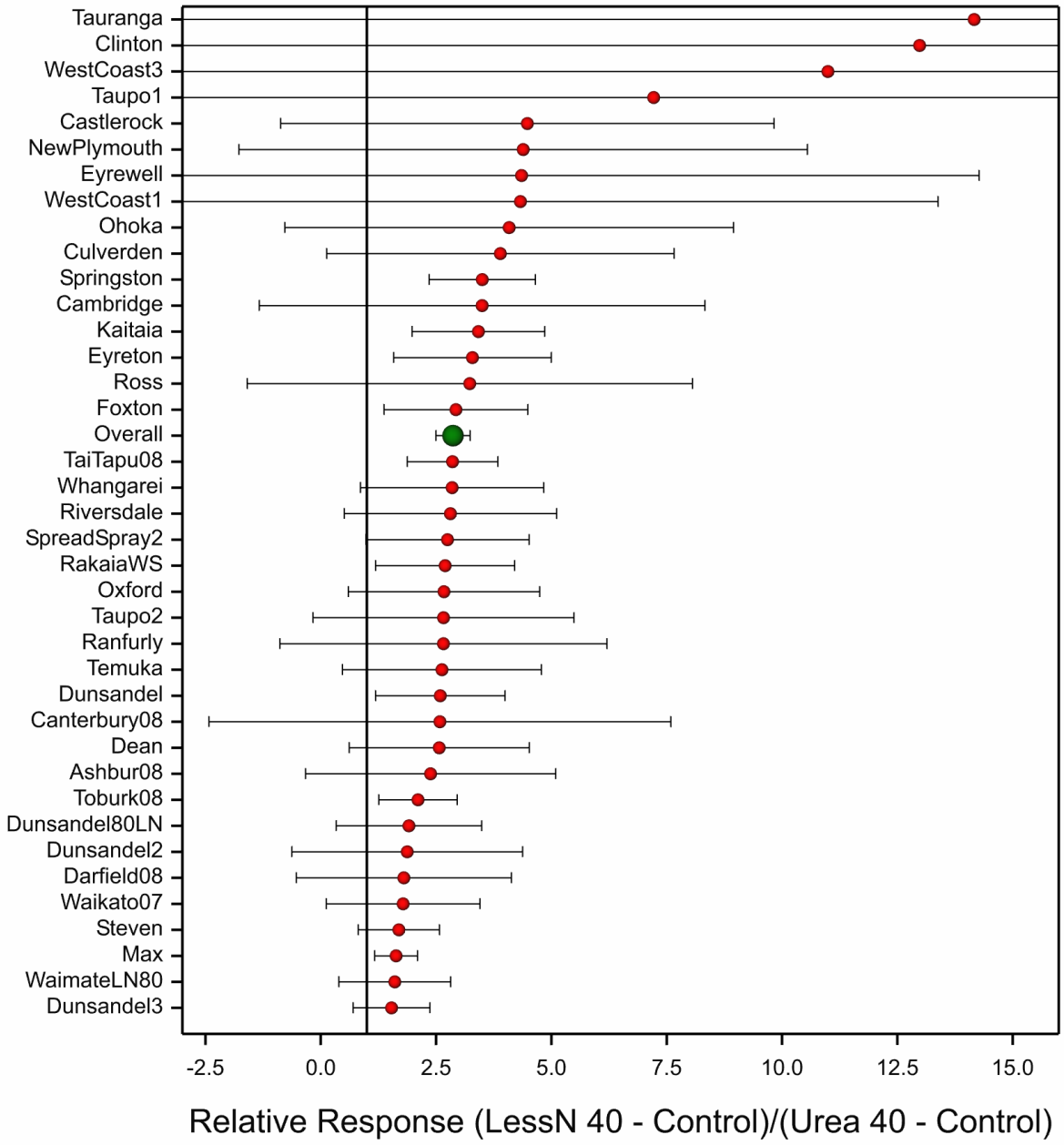


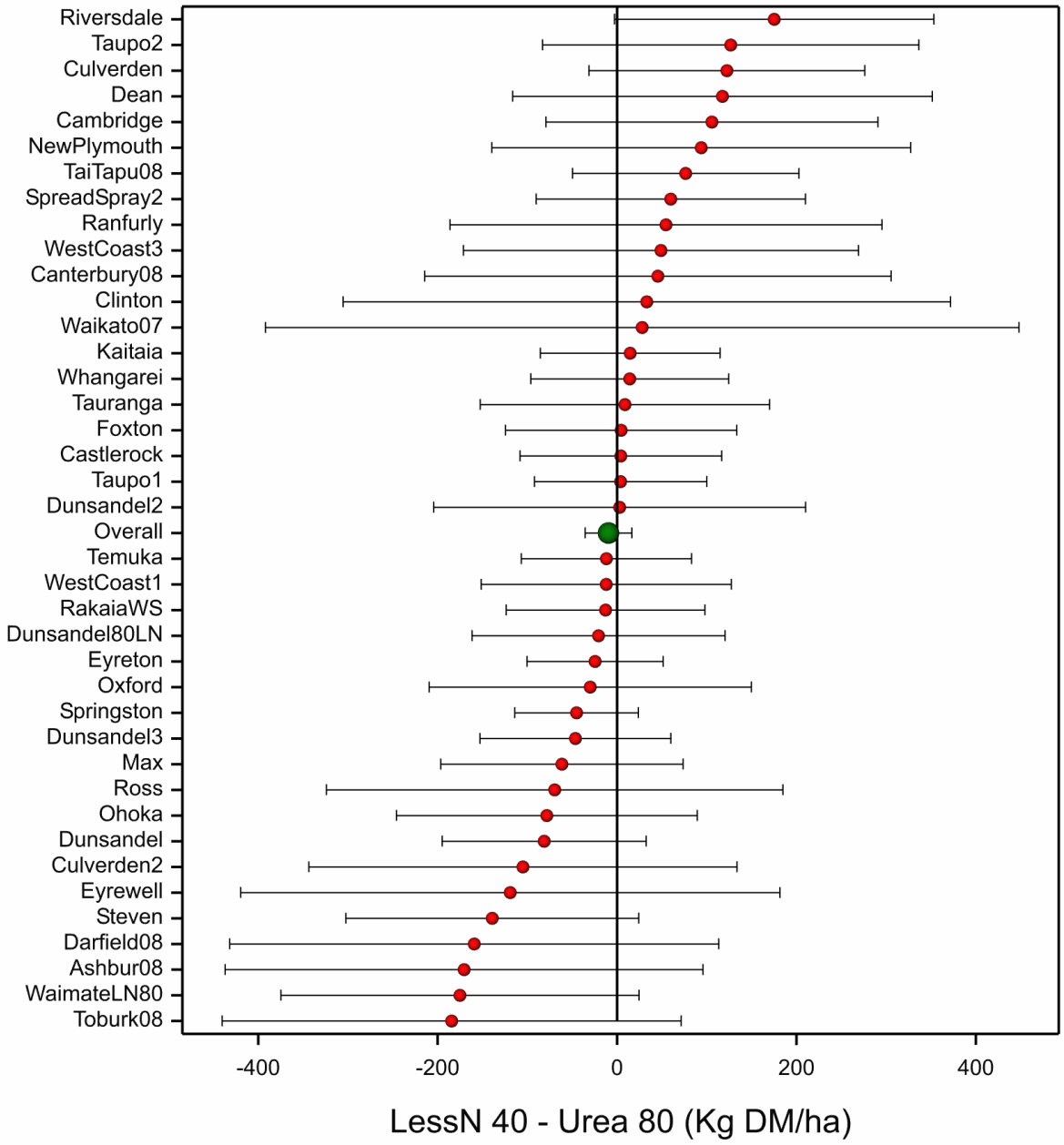
Estimation of LessN40 Effect in comparison to Urea80 and Urea40 for Urea80:Urea40 ratio >1.75 ("good relative Urea80 response")

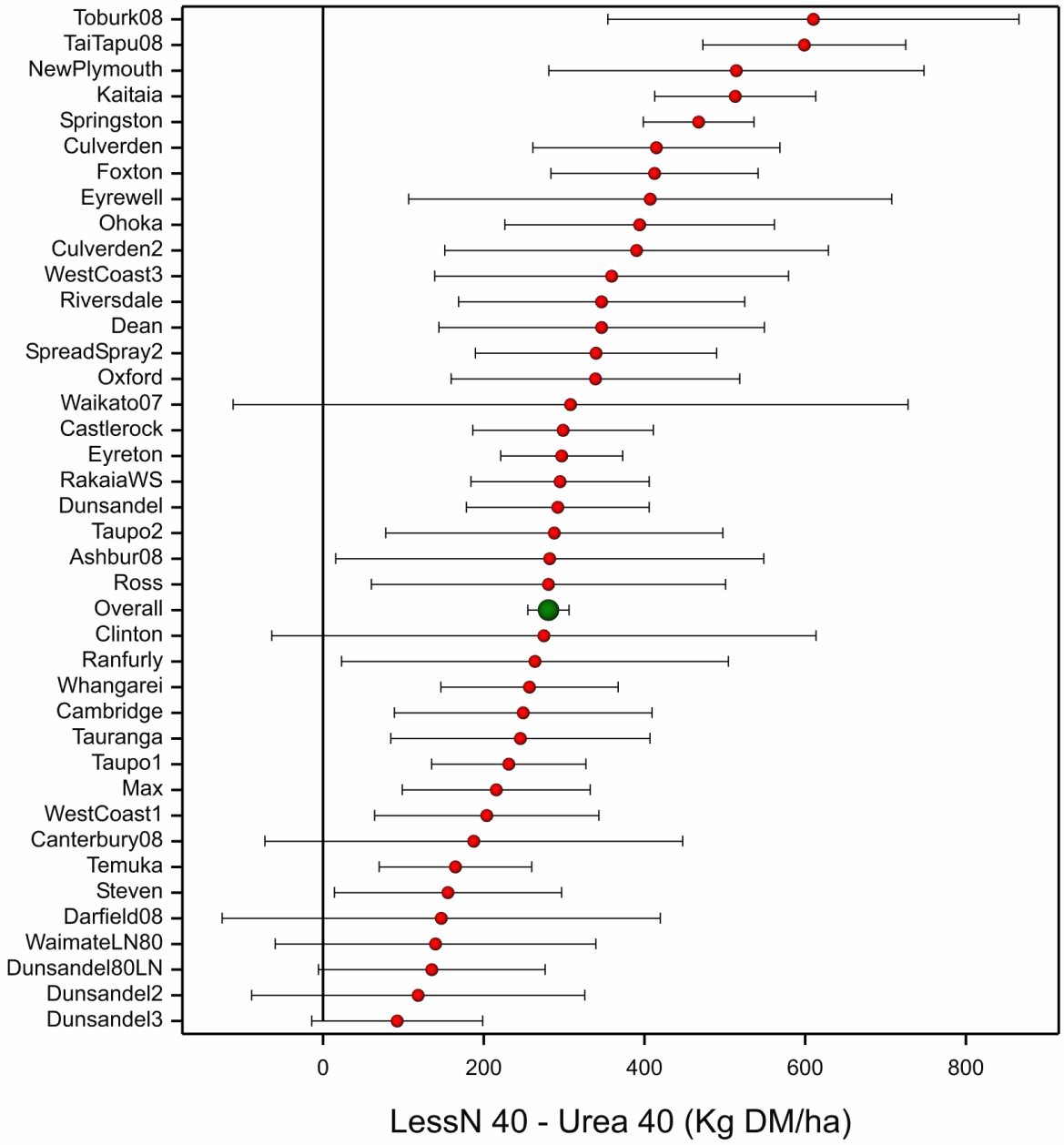
"Good Urea80 Response" 39 Trials	Mean	LowCI95%	HighCI95%	lsd
Absolute Difference (LessN40-N40) (kg/ha)	280	255	306	26
LessN40:N40 Response Ratio	2.87	2.50	3.24	
LessN40:N80 Response Ratio*	0.98	0.92	1.04	

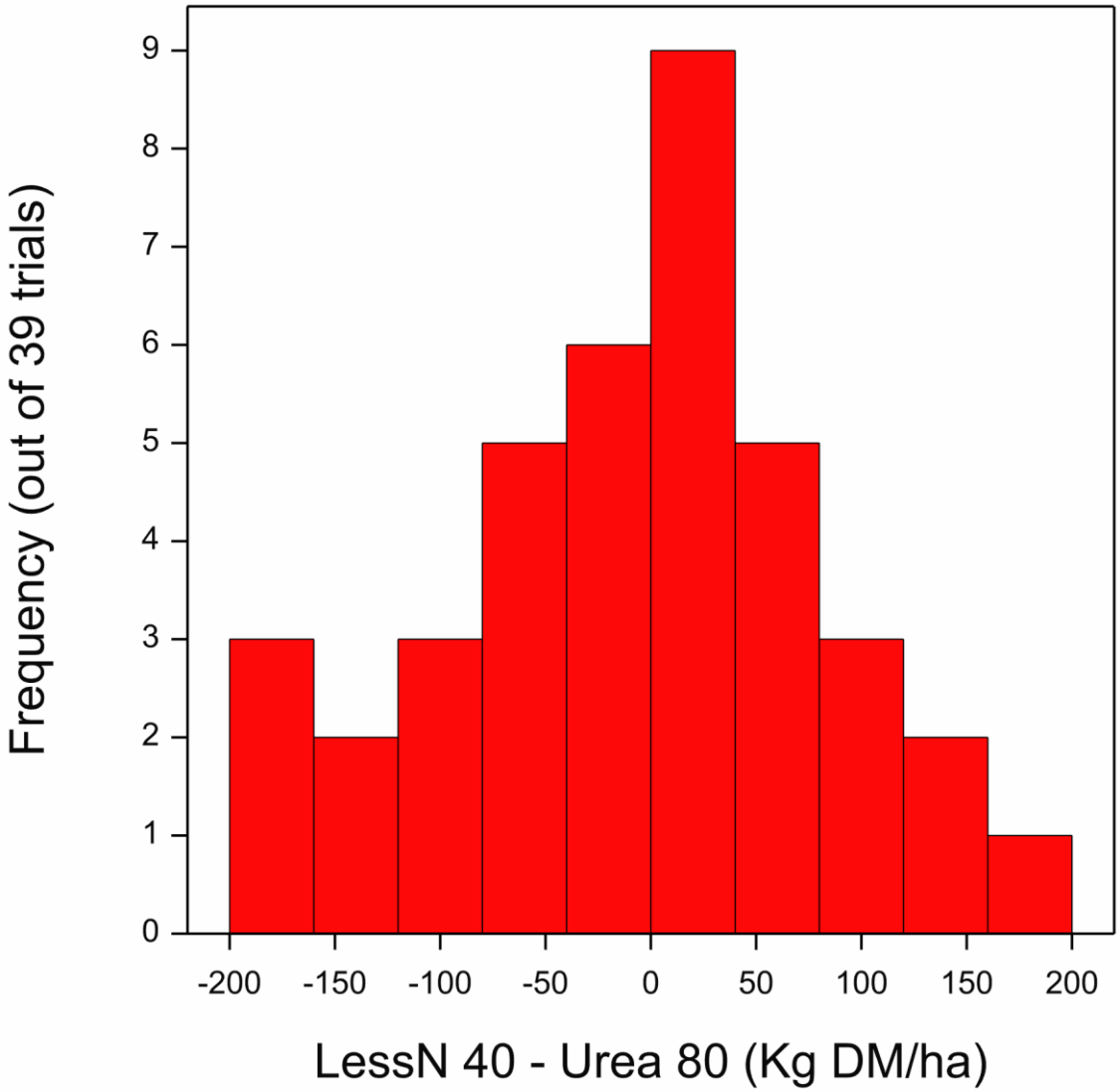
*** Solid and Liquid Urea80 results combined**

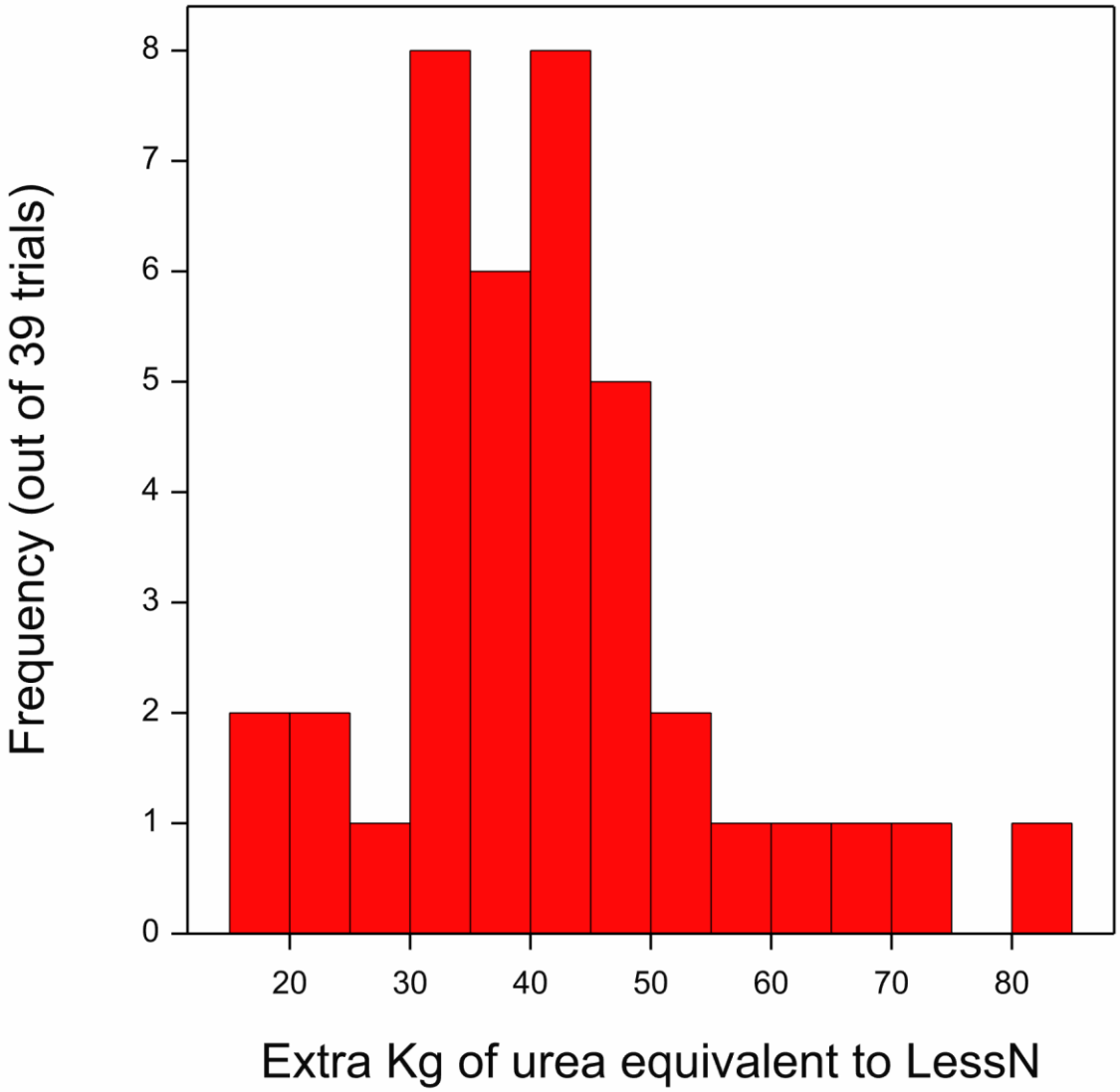


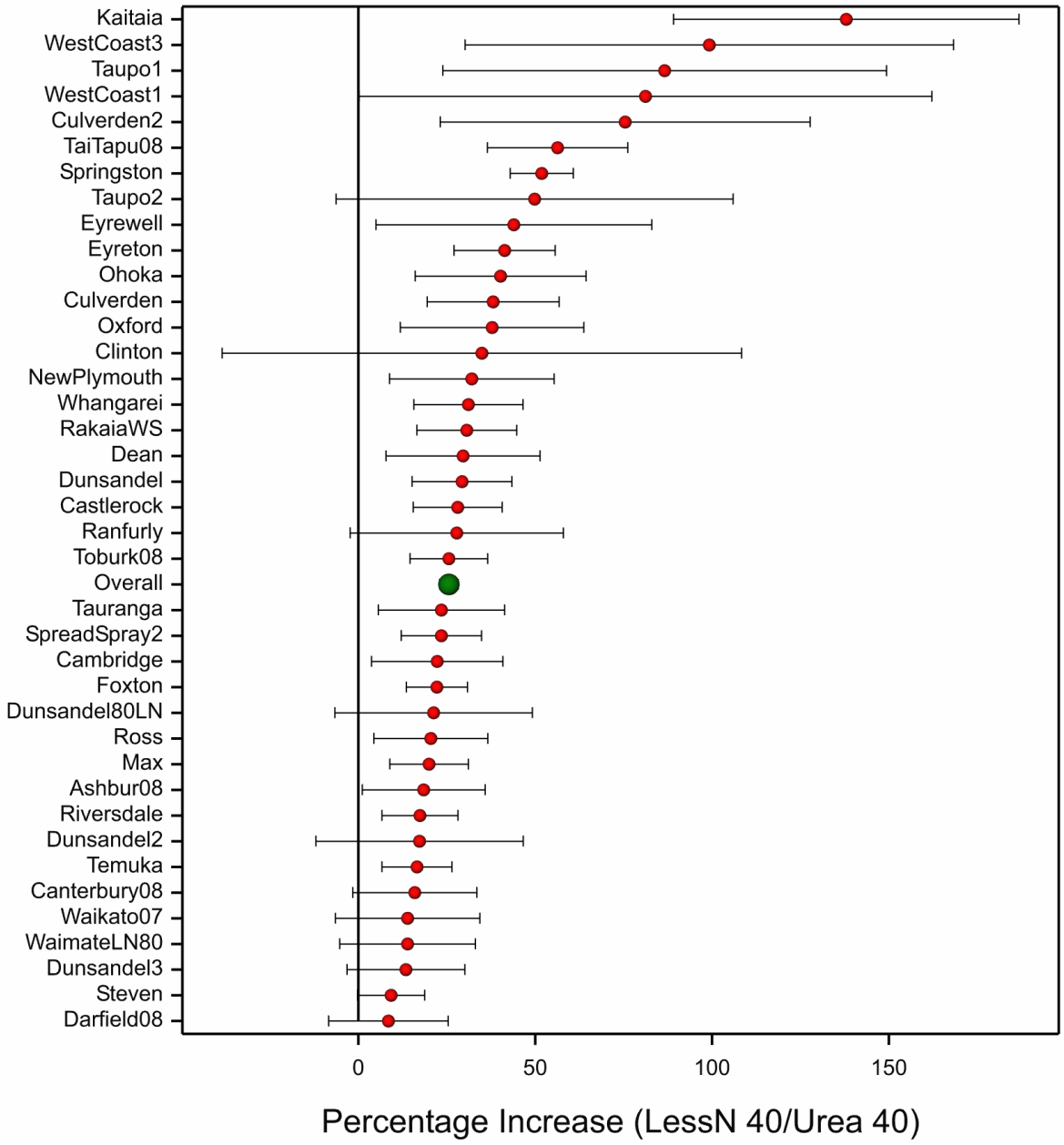

Tauranga
Clinton
WestCoast3
Taupo1
Castlerock
NewPlymouth
Eyrewell
WestCoast1
Ohoka
Culverden
Springston
Cambridge
Kaitaia
Eyreton
Ross
Foxton
Overall
TaiTapu08
Whangarei
Riversdale
SpreadSpray2
RakaiaWS
Oxford
Taupo2
Ranfurly
Temuka
Dunsandel
Canterbury08
Dean
Ashbur08
Toburk08
Dunsandel80LN
Dunsandel2
Darfield08
Waikato07
Steven
Max
WaimateLN80
Dunsandel3
-2.5
0.0
2.5
5.0
7.5
10.0
12.5
15.0
Relative Response (LessN 40 - Control)/(Urea 40 - Control)


Riversdale
Taupo2
Culverden
Dean
Cambridge
NewPlymouth
TaiTapu08
SpreadSpray2
Ranfurly
WestCoast3
Canterbury08
Clinton
Waikato07
Kaitaia
Whangarei
Tauranga
Foxton
Castlerock
Taupo1
Dunsandel2
Overall
Temuka
WestCoast1
RakaiaWS
Dunsandel80LN
Eyreton
Oxford
Springston
Dunsandel3
Max
Ross
Ohoka
Dunsandel
Culverden2
Eyrewell
Steven
Darfield08
Ashbur08
WaimateLN80
Toburk08
-400
-200
0
200
400
LessN 40 - Urea 80 (Kg DM/ha)


Toburk08
TaiTapu08
NewPlymouth
Kaitaia
Springston
Culverden
Foxton
Eyrewell
Ohoka
Culverden2
WestCoast3
Riversdale
Dean
SpreadSpray2
Oxford
Waikato07
Castlerock
Eyreton
RakaiaWS
Dunsandel
Taupo2
Ashbur08
Ross
Overall
Clinton
Ranfurly
Whangarei
Cambridge
Tauranga
Taupo1
Max
WestCoast1
Canterbury08
Temuka
Steven
Darfield08
WaimateLN80
Dunsandel80LN
Dunsandel2
Dunsandel3
0
200
400
600
800
LessN 40 - Urea 40 (Kg DM/ha)

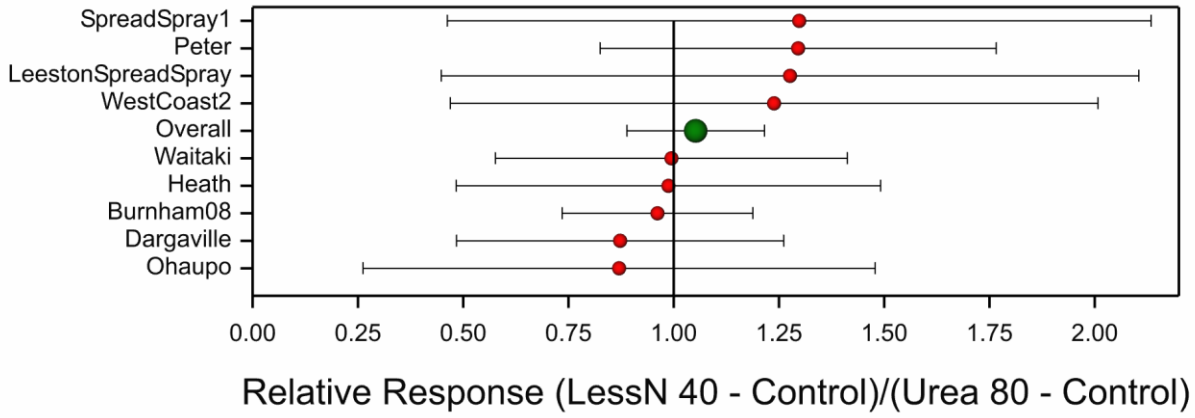

Frequency (out of 39 trials)
0
1
2
3
4
5
6
7
8
9
-200
-150
-100
-50
0
50
100
150
200
LessN 40 - Urea 80 (Kg DM/ha)

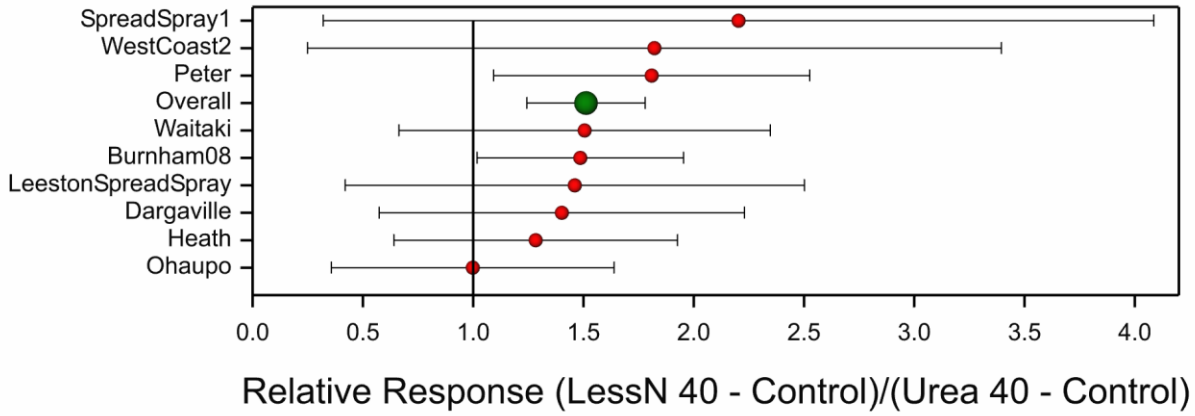

Frequency (out of 39 trials)
0
1
2
3
4
5
6
7
8
20
30
40
50
60
70
80
Extra Kg of urea equivalent to LessN

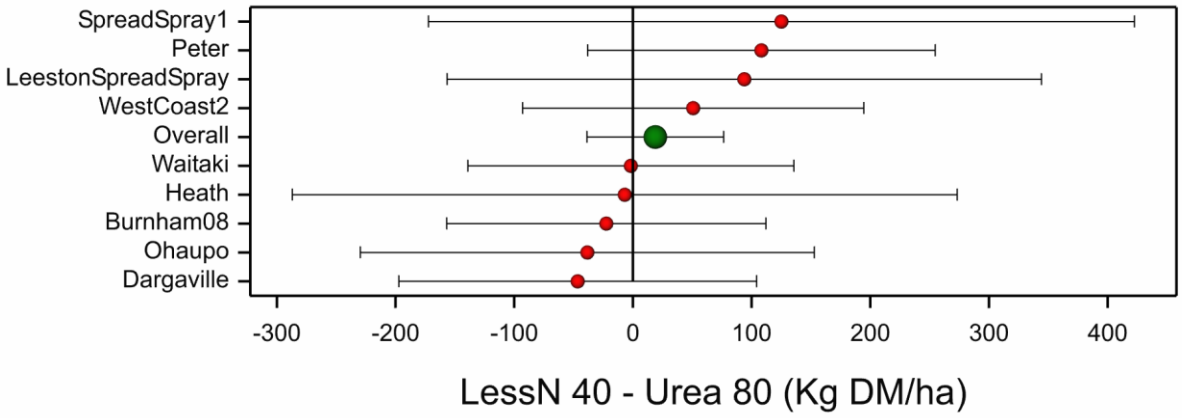

Kaitaia
WestCoast3
Taupo1
WestCoast1
Culverden2
TaiTapu08
Springston
Taupo2
Eyrewell
Eyreton
Ohoka
Culverden
Oxford
Clinton
NewPlymouth
Whangarei
RakaiaWS
Dean
Dunsandel
Castlerock
Ranfurly
Toburk08
Overall
Tauranga
SpreadSpray2
Cambridge
Foxton
Dunsandel80LN
Ross
Max
Ashbur08
Riversdale
Dunsandel2
Temuka
Canterbury08
Waikato07
WaimateLN80
Dunsandel3
Steven
Darfield08
0
50
100
150
Percentage Increase (LessN 40/Urea 40)

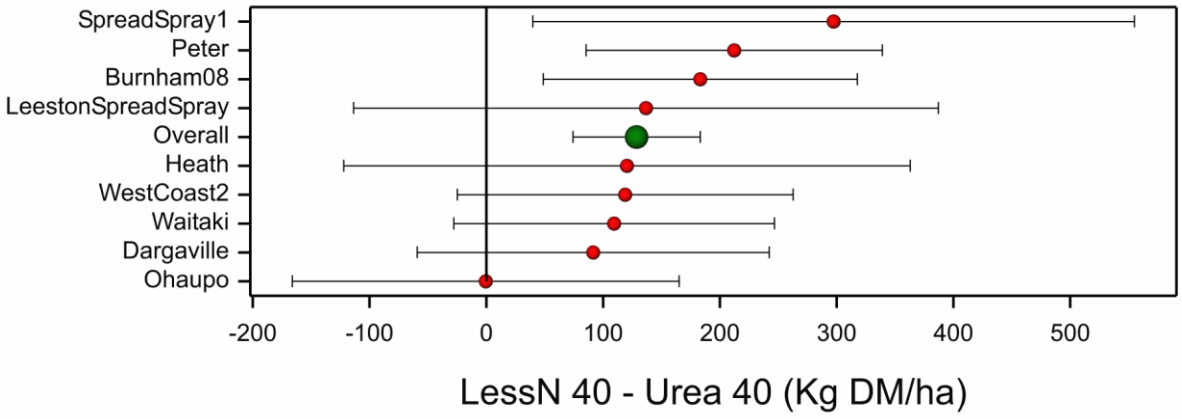
Estimation of LessN40 Effect in comparison to Urea80 and Urea40 for Urea80:Urea40 ratio <1.75 ("poor relative Urea80 response")

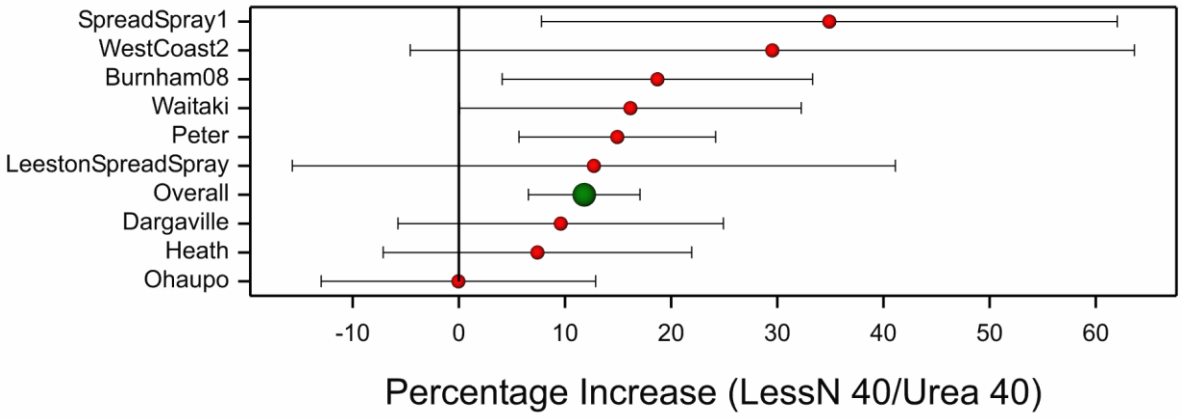
"Poor Urea80 Response" 9 Trials	Mean	LowCI95%	HighCI95%	lsd
Absolute Difference (LessN40-N40) (kg/ha)	129	74	183	54
LessN40:N40 Response Ratio	1.51	1.24	1.78	
LessN40:N80 Response Ratio	1.05	0.89	1.22	






SpreadSpray1
Peter
LeestonSpreadSpray
WestCoast2
Overall
Waitaki
Heath
Burnham08
Ohaupo
Dargaville
-300
-200
-100
0
100
200
300
400
LessN 40 - Urea 80 (Kg DM/ha)


SpreadSpray1
Peter
Burnham08
LeestonSpreadSpray
Overall
Heath
WestCoast2
Waitaki
Dargaville
Ohaupo
-200
-100
0
100
200
300
400
500
LessN 40 - Urea 40 (Kg DM/ha)


SpreadSpray1
WestCoast2
Burnham08
Waitaki
Peter
LeestonSpreadSpray
Overall
Dargaville
Heath
Ohaupo
-10
0
10
20
30
40
50
60
Percentage Increase (LessN 40/Urea 40)