

Supplementary information.

“Potential to improve Nitrogen Use Efficiency (NUE) by use of Perennial Mobile Green Manures” Nutrient Cycling in Agroecosystems, C R Ward, D R Chadwick, P W Hill. Bangor University (UK)

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Supplementary information on methods and materials.

Pot experiment

Green manure collection and processing; Clover, alder and gorse were cut in October 2016 from plants growing at Henfaes Research Station in Abergwyngregyn (53°14'N, 4°01'W); and gunnera from pot-grown plants and stored in polythene bags at 4 °C prior to use. Alder, gunnera and clover were of leaves only (including petioles), and gorse consisted of leaves and stems of ≤ 5 mm width.

Soil solution sampling: Soil solution was sampled using 50 mm Rhizon™ soil solution samplers (male Luer 19.21.22, Rhizosphere research products, Wageningen, Netherlands) inserted at a c. 45 ° angle, to a depth of c. 70 mm, which remained in place throughout the experiment. Soil solution (ca. 2 ml on each sampling occasion) was drawn out via a needle fitted to a 9 ml vacuum tube and stored at -20 °C until analysis.

Measurement of N dynamics using AN140 and AN200 as an additional experiment: The soil of the additional experiment (with treatments of control, AN70, AN140 and AN200) had the same characteristics as that of the main experiment, with the exception of pH (6.1) and potassium (146 ± 4 mg L⁻¹ fresh soil). It was considered valid to use the data collected from the AN140 and AN200 treatments, alongside the data from the main experiment for a parameter when the results of the control and AN70 treatments did not differ between the additional and main experiment either in the actual amounts, or the proportional difference between the 70 kg N ha⁻¹ treatment and the control. Differences for each parameter were determined by a t-test as shown in Tables S5a/b.

Field Experiment

PMGM collection and processing: PMGM material was cut in May 2017, and September 2017 for year 1 and year 2 respectively. The alder and gorse were taken from plants growing at Henfaes Research Station in Abergwyngregyn (53°14'N, 4°01'W) and gunnera from plants on land at 52°37'17"N, 003°50'52"W. Material requiring drying was spread on benches in a well-ventilated greenhouse until dry and stored at room temperature. It was otherwise processed as for the pot experiment, and characteristics shown in Table S3.

Year 1 Soil preparation: Livestock had been excluded from the experimental area for > 6 months before the experiment began. Four weeks prior to the experiment, the soil was ploughed. Before the experimental treatments, additions to soil as shown in Table S2 were applied by hand for a target pH of 6.5 to ensure that crop growth was not limited by an inappropriate pH, or lack of nutrients other than N. Additions were based on analyses by NRM laboratories (Cawood scientific, Bracknell, UK) and recommendations by UK fertiliser guidelines (Defra 2010; AHDB 2018). Soil was tilled to a depth of 100 mm.

Year 1 Addition of treatments: Mulched PMGMs were applied on the soil surface (but leaving strips of bare soil to allow sowing). Incorporated treatments of fresh and dried alder were dug in by hand to a depth of 100 mm. NH_4NO_3 was added in solution, evenly over the soil surface, and the same volume of distilled water added to all replicates not receiving NH_4NO_3 .

Year 2 Soil preparation: Two days before sowing, additions to soil as shown in Table S2 were applied by hand, and plots were hand cultivated to a depth of 50 mm.

Year 2 Pest prevention: After sowing, plots were covered with wire gabions to exclude corvids and on day 76 were netted (approx. 10 mm holes) to exclude rabbits and birds. Loss to rodents, estimated by the number of stems missing ears on harvest was less than 2 %, with no difference in loss between treatments.

Year 2 Measurement of potential ammonia volatilisation: Potential ammonia volatilisation was measured by trapping NH_3 in H_2SO_4 solution as follows. Inverted plastic containers of 85 by 286 mm, and a height of 60 mm were inserted 5mm into soil (between plants), trapping air above a soil surface area of 0.0239 m^2 (accounting for rounded corners). HDPE scintillation vials (20 ml) containing 5 ml of 0.01 M H_2SO_4 were placed inside the chambers and removed and replaced approximately every 14 days, and the H_2SO_4 solution stored at -20°C until analyses for NH_4^+ . H_2SO_4 solutions were analysed for NH_4^+ as described in Mulvaney (1996) using PowerWave XS BioTek spectrophotometer (Winooski, VT, US) using Gen 5 software. Potential NH_3 emissions were calculated from the amount of NH_4^+ N trapped in solution which was assumed to be equal to the amount of NH_3 -N emitted from the soil surface area of each trap. The emission factors (EFs) were calculated by subtracting the cumulative NH_3 emissions for the control replicates from the cumulative emissions of the treatment replicates (paired by block) and dividing by the amount of N added (Nett et al. 2016). H_2SO_4 traps after day 26 were discarded due to insects in traps.

References

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- Nett L, Sradnick A, Fuss R, Flessa H, Fink M (2016) Emissions of nitrous oxide and ammonia after cauliflower harvest are influenced by soil type and crop residue management. *Nutrient Cycling in Agroecosystems*, 106(2), 217-231. <https://doi.org/10.1007/s10705-016-9801-2>

Table S1 Background soil characteristics prior to the pot experiment and field experiment year 1. Means $\pm$ SEM, Pot $n = 5$, Field $n = 4$. Field soil pH and all K and P values are single measures obtained from NRM laboratories (Cawood Sciencific, Bracknell, UK).

Soil Property	Pot Experiment	Field Experiment
pH	5.7 $\pm$ < 0.1	5.6
Total soil C (g C kg ⁻¹ dry soil)	21.9 $\pm$ 0.9	26.5 $\pm$ 0.9
Total soil N (g N kg ⁻¹ dry soil)	2.21 $\pm$ 0.10	2.42 $\pm$ 0.10
Soil C:N ratio	9.9 $\pm$ 0.5	11.0 $\pm$ 0.2
DOC (^a mg C L ⁻¹ soil solution ^b mg C kg ⁻¹ dry soil)	^a 14 $\pm$ 3	^b 135 $\pm$ 7
TDN (^a mg TDN L ⁻¹ soil solution ^b mg TDN kg ⁻¹ dry soil)	^a 24 $\pm$ 2	^b 30 $\pm$ 3
NO ₃ ⁻ (^a mg N L ⁻¹ soil solution ^b mg N kg ⁻¹ dry soil)	^a 19 $\pm$ 2	^b 17 $\pm$ 3
NH ₄ ⁺ (^a mg N L ⁻¹ soil solution ^b mg N kg ⁻¹ dry soil)	^a 0.04 $\pm$ 0.03	^b 3.29 $\pm$ 1.00
Available P (mg L ⁻¹ fresh soil)	35	48
Available K (mg L ⁻¹ fresh soil)	103	169
Bulk Density (g cm ⁻³)	1.06	1.12 $\pm$ 0.09

^a DOC/TDN/ NO₃⁻/NH₄⁺ measured in soil solution extracted by Rhizons™ prior to treatment addition. ^b DOC/N/ NO₃⁻/NH₄⁺ measured in extractions of soil prior to treatments and calculation per kg dry soil.

Table S2 Non-N additions to soil prior to each experiment.

Experiment	Recommended for	Additions
Pot	Grass establishment	16 kg ha ⁻¹ S, 66.4 kg ha ⁻¹ K and 13.2 kg ha ⁻¹ P
Field year 1	Spring cereal crop	100 kg ha ⁻¹ Keiserite (MgSO ₄ ·H ₂ O) and 116 kg ha ⁻¹ K 900 kg ha ⁻¹ Calcifert
Field year 2	Spring wheat	100 kg ha ⁻¹ Kesperite (MgSO ₄ ·H ₂ O) and 83 kg ha ⁻¹ K 600 kg ha ⁻¹ Calcifert

Table S3 Characteristics of green manures added to the pot and field experiments. Means $\pm$ SEM (Pot $n = 3$, Field $n = 4$).

Plant species	Experiment	Processing	Carbon (g kg ⁻¹ dry leaf)	Nitrogen (g kg ⁻¹ dry leaf)	C:N ratio
Clover (<i>Trifolium pratense</i>)	Pot	Fresh	486 $\pm$ 1	48.1 $\pm$ 4.0	10.1 $\pm$ 0.1
Alder (<i>Alnus glutinosa</i>)	Pot	Fresh	511 $\pm$ 1	33.8 $\pm$ 0.1	15.1 $\pm$ 0.01
	Field year 1	Fresh	507 $\pm$ 2	27.5 $\pm$ 0.3	18.5 $\pm$ 0.2
	Field year 1	Dried	530 $\pm$ 1	41.2 $\pm$ 0.3	12.0 $\pm$ 0.1
	Field year 2	Dried	472 $\pm$ 1	28.4 $\pm$ 0.04	16.6 $\pm$ 0.04
Gunnera (<i>Gunnera tinctoria</i>)	Pot	Fresh	467 $\pm$ 2	22.8 $\pm$ 0.4	20.5 $\pm$ 0.3
	Field year 1	Dried	458 $\pm$ 1	30.2 $\pm$ 0.4	15.2 $\pm$ 0.2
	Field year 2	Dried	376 $\pm$ 2	16.9 $\pm$ 0.1	22.2 $\pm$ 0.1
Gorse (<i>Ulex europaeus</i>)	Pot	Fresh	529 $\pm$ 1	19.8 $\pm$ 0.2	26.8 $\pm$ 0.2
	Field year1	Dried	525 $\pm$ 2	26.7 $\pm$ 1.3	19.8 $\pm$ 1.1

Table S4 Pot experiment. Mean average air temperature (°C) during each grass growth period.

Time Period (Days)	0 to 31	32 to 59	60 to 94	95 to 129	130 to 164	165 to 199	200 to 234	235 to 269	270 to 304	305 to 339
Main	17.5	16.3	16.3	20.8	19.7	20.8	28.8	26.8	27.3	22.8
Additional	17.0	16.5	17	17.5	20	22	27	23	22	18

Table S5a. P values from t-tests between the cumulative shoot N uptake data of the control from the main pot experiment and the control of the additional^a pot experiment, and similarly for the two sets of AN70 data. If the values for the control and AN70 did not differ between the two experiments, all data from both experiments were presented and analysed together.

Day	31	59	94	129	164	199	234	269	304	340	364	Root
P Value control	0.32	0.64	0.50	0.50	0.79	0.80	0.34	0.14	0.41	0.65	0.74	0.80
P Value AN70	0.0007	0.93	0.85	0.81	0.68	0.75	0.42	0.35	0.47	0.57	0.54	0.72

^aThe treatments of AN140 and AN200 were assessed in an addition to the main experiment, which was conducted at a later date. This additional experiment included the control and AN70 treatments alongside the two higher fertiliser treatments and followed the same methods as the main experiment. It was considered valid to use the data collected from the AN140 and AN200 treatments, alongside the data from the main experiment for a parameter when the results of the control and AN70 treatments did not differ between the additional and main experiment either in the actual amounts, or the proportional difference between the 70 kg N ha⁻¹ treatment and the control.

Table S5b. P values from t.tests between the total shoot N uptake/total whole plant N uptake and root:shoot ratio data of the control from the main pot experiment and the control of the additional^a pot experiment, and similarly for the two sets of AN70 data. If the values for the control and AN70 did not differ between the two experiments, all data from both experiments were presented and analysed together.

Measurement	Control	AN70
Shoot N (g m ⁻²)	0.74	0.54
Whole Plant N (g m ⁻²)	0.95	0.71
Root:Shoot ratio	0.59	0.55

^aThe treatments of AN140 and AN200 were assessed in an addition to the main experiment, which was conducted at a later date. This additional experiment included the control and AN70 treatments alongside the two higher fertiliser treatments and followed the same methods as the main experiment. It was considered valid to use the data collected from the AN140 and AN200 treatments, alongside the data from the main experiment for a parameter when the results of the control and AN70 treatments did not differ between the additional and main experiment either in the actual amounts, or the proportional difference between the 70 kg N ha⁻¹ treatment and the control.

Table S6a Field experiment year 1 (2017) Weekly mean soil surface temperatures and total weekly precipitation

Time period (Days)	Mean temp (°C)	Rainfall (mm)
0 to 6	19.6	1.5
7 to 13	17.1	0.3
14 to 20	19.6	0.2
21 to 27	20.0	0.0
28 to 34	19.4	0.0
35 to 41	16.8	0.7
42 to 48	17.9	0.8
59 to 55	17.2	4.5
56 to 62	17.6	0.0
63 to 69	17.8	4.3
70 to 76	16.1	0.8
77 to 83	15.1	0.2
84 to 90	13.8	0.2
91 to 97	14.9	0.0
98 to 105	13.6	2.8
Mean temperature (°C)	17.1	
Total rain (mm)		16.2

Table S6b Field experiment year 2 (2018) Weekly mean soil surface temperatures and total weekly precipitation

Time period (Days)	Mean temp (°C)	Rainfall (mm)
0 to 6	10.6	10.7
7 to 13	14.6	1.5
14 to 20	13.7	6.3
21 to 27	15.3	0.0
28 to 34	18.0	11.1
35 to 41	18.1	0.2
42 to 48	18.9	0.0
59 to 55	18.1	2.1
56 to 62	19.5	0.0
63 to 69	22.2	0.0
70 to 76	22.4	0.0
77 to 83	21.3	3.8
84 to 90	20.4	11.6
91 to 97	19.2	17.7
98 to 104	20.0	1.5
105 to 111	18.4	17.2
Mean temperature (°C)	18.2	
Total rain (mm)		83.5

Table S7 Treatments added in the field experiment. AN = NH₄NO₃, F = fresh, D = dry, Inc = incorporated, M = mulched. Plots treated with Alder F Inc, Alder F M, Alder D Inc and Gorse D M were discontinued in year 2. Plots treated with AN200, Alder DM (Ald) and Gunnera DM (Gun) were split into two plots in year two with one half receiving a repeated treatment and the other half receiving no treatment.

Treatments added in Year 1			Treatments added in Year 2		
Treatment code	N (kg N ha ⁻¹)	Material (kg ha ⁻¹)	Treatment code	N (kg N ha ⁻¹)	Material (kg ha ⁻¹)
Control	0	0	Control	0	0
AN25	25	71.43	AN 25 + 25	25	71.43
AN50	50	142.86	AN 50 + 50	50	142.86
AN100	100	285.71	AN 100 + 100	100	285.71
AN200	200	571.43	AN 200 + 0	0	0
			AN 200 + 200	200	571.43
Alder F Inc	200	20,205			
Alder F M	200	20,205			
Alder D Inc	200	4,854			
Alder D M	200	4,854	Ald + 0	0	0
			Ald + Ald	200	7,032
Gorse D M	200	7,436			
Gunnera D M	200	6,660	Gun + 0	0	0
			Gun + Gun	200	11,832

Table S8a % N (dry weight) in shoot and root tissue harvested from the main and additional^b experiments of the pot experiment, after addition of 200 kg N ha⁻¹ within clover, alder, and gunnera and NH₄NO₃ at N 35/70/140/200 kg ha⁻¹ Means ± SEM, (*n* = 5).

Experiment	Treatment	Day 31	Day 59	Day 94	Day 129	Day 164	Day 199	Day 234	Day 269	Day 304	Day 340	Day 364	Root
Main	Control	3.5 ± 0.12	2.5 ± 0.06	2.0 ± 0.04	1.7 ± 0.04	1.7 ± 0.04	1.7 ± 0.04	1.7 ± 0.09	1.2 ± 0.03	1.2 ± 0.03	1.2 ± 0.03	0.9 ± 0.03	1.0 ± 0.03
Additional	Control	2.6 ± 0.06	1.8 ± 0.08	1.7 ± 0.04	1.4 ± 0.03	1.7 ± 0.09	1.2 ± 0.04	1.5 ± 0.08	1.1 ± 0.03	1.1 ± 0.03	1.3 ± 0.03	0.8 ± 0.05	1.0 ± 0.05
Main	AN 35	4.8 ± 0.05	2.6 ± 0.07	1.8 ± 0.02	1.7 ± 0.04	1.7 ± 0.04	1.7 ± 0.04	1.8 ± 0.07	1.2 ± 0.04	1.2 ± 0.04	1.2 ± 0.04	0.9 ± 0.03	0.9 ± 0.04
Main	AN 70	5.3 ± 0.12	3.6 ± 0.56	1.6 ± 0.00	1.6 ± 0.03	1.6 ± 0.03	1.6 ± 0.03	1.7 ± 0.06	1.2 ± 0.02	1.2 ± 0.02	1.2 ± 0.02	1.0 ± 0.04	0.9 ± 0.05
Additional	AN 70	4.0 ± 0.24	1.8 ± 0.09	1.6 ± 0.01	1.3 ± 0.04	1.7 ± 0.08	1.3 ± 0.04	1.4 ± 0.05	1.1 ± 0.01	1.2 ± 0.04	1.4 ± 0.05	0.9 ± 0.07	0.9 ± 0.05
Additional	AN140	5.3 ± 0.19	2.0 ± 0.21	1.4 ± 0.05	1.3 ± 0.03	1.5 ± 0.06	1.4 ± 0.07	1.6 ± 0.04	1.1 ± 0.03	1.2 ± 0.08	1.4 ± 0.06	0.9 ± 0.01	1.0 ± 0.05
Additional	AN 200	5.6 ± 0.07	2.6 ± 0.18	1.4 ± 0.03	1.3 ± 0.03	1.6 ± 0.09	1.4 ± 0.03	1.6 ± 0.07	1.1 ± 0.03	1.1 ± 0.06	1.4 ± 0.07	0.9 ± 0.04	1.0 ± 0.03
Main	Clover	5.7 ± 0.05	4.5 ± 0.23	1.8 ± 0.03	1.6 ± 0.02	1.6 ± 0.02	1.6 ± 0.02	1.7 ± 0.09	1.2 ± 0.04	1.2 ± 0.04	1.2 ± 0.04	0.9 ± 0.05	0.9 ± 0.05
Main	Alder	4.4 ± 0.11	3.4 ± 0.20	2.0 ± 0.08	1.6 ± 0.03	1.6 ± 0.03	1.6 ± 0.03	1.7 ± 0.03	1.3 ± 0.04	1.3 ± 0.04	1.3 ± 0.04	0.9 ± 0.04	1.0 ± 0.07
Main	Gunnera	3.3 ± 0.06	3.0 ± 0.40	2.2 ± 0.12	1.6 ± 0.03	1.6 ± 0.03	1.6 ± 0.03	1.8 ± 0.10	1.2 ± 0.02	1.2 ± 0.02	1.2 ± 0.02	0.7 ± 0.04	1.1 ± 0.07
Main	Gorse	4.5 ± 0.10	2.6 ± 0.04	1.9 ± 0.05	1.7 ± 0.03	1.7 ± 0.03	1.7 ± 0.03	1.8 ± 0.09	1.3 ± 0.04	1.3 ± 0.04	1.3 ± 0.04	0.9 ± 0.02	1.0 ± 0.04

^b See explanation in Table S5

Table S8b Pot experiment cumulative N content (g m⁻²) of successive harvests of above ground grass biomass as shown in Fig 1. Treatments were no addition (control), 200 kg N ha⁻¹ equivalent in clover, alder, gunnera and gorse leaf tissue, and NH₄NO₃ (AN) from 70 to 200 kg N ha⁻¹ as stated in the key. N contents on day 31 for AN 140 and 200 are not included due to differences in control and AN70 data between the main and additional experiment (Table S5a). Letters denote significant differences as *P* < 0.05) Means ± SEM (*n* = 5).

Day	31	59	94	129	164	199	234	269	304	340	364
Control	2.2 ± 0.2 ab	3.3 ± 0.3 a	4.1 ± 0.4 a	4.7 ± 0.4 a	5.4 ± 0.4 a	6.2 ± 0.4 a	7.6 ± 0.3 a	8.8 ± 0.3 a	9.4 ± 0.2 a	9.8 ± 0.2 a	10.6 ± 0.2 a
AN 35	4.9 ± 0.1 d	6.2 ± 0.1 b	7.2 ± 0.2 b	7.8 ± 0.2 b	8.4 ± 0.2 b	9.2 ± 0.3 b	10.5 ± 0.3 b	11.7 ± 0.2 b	12.3 ± 0.2 b	12.6 ± 0.3 b	13.6 ± 0.3 b
AN 70	6.1 ± 0.1 e	9.0 ± 0.5 c	10.0 ± 0.5 c	10.6 ± 0.5 d	11.3 ± 0.5 d	12.0 ± 0.5 c	13.3 ± 0.5 c	14.5 ± 0.5 c	15.1 ± 0.5 c	15.4 ± 0.5 c	16.3 ± 0.6 c
AN 140		13.4 ± 0.2 d	14.5 ± 0.2 d	15.0 ± 0.2 e	15.6 ± 0.2 e	16.3 ± 0.3 d	17.3 ± 0.2 d	18.4 ± 0.2 d	19.0 ± 0.2 d	19.5 ± 0.2 d	20.5 ± 0.3 d
AN 200		17.1 ± 0.3 e	18.6 ± 0.3 e	19.2 ± 0.3 f	19.8 ± 0.4 f	20.5 ± 0.3 e	21.4 ± 0.4 e	22.5 ± 0.3 e	23.2 ± 0.3 e	23.7 ± 0.3 e	24.6 ± 0.3 e
Clover	7.0 ± 0.2 e	12.2 ± 0.6 d	14.2 ± 0.5 d	15.2 ± 0.5 e	15.9 ± 0.5 e	16.6 ± 0.5 d	17.9 ± 0.6 d	19.2 ± 0.6 d	19.8 ± 0.6 d	20.2 ± 0.6 d	21.2 ± 0.6 d
Alder	3.2 ± 0.1 bc	6.5 ± 0.6 b	8.7 ± 0.6 bc	9.8 ± 0.6 cd	10.8 ± 0.6 cd	12.0 ± 0.6 c	13.6 ± 0.6 c	15.1 ± 0.6 c	15.7 ± 0.6 c	16.2 ± 0.6 c	17.2 ± 0.6 c
Gunnera	1.8 ± 0.1 a	3.5 ± 0.5 a	5.8 ± 0.7 a	7.8 ± 0.5 b	9.3 ± 0.5 bc	10.7 ± 0.4 bc	12.8 ± 0.3 c	14.7 ± 0.3 c	15.4 ± 0.3 c	15.8 ± 0.3 c	17.0 ± 0.2 c
Gorse	3.9 ± 0.1 cd	5.7 ± 0.2 b	7.3 ± 0.1 b	8.1 ± 0.1 bc	9.0 ± 0.1 bc	10.1 ± 0.1 b	12.1 ± 0.2 c	13.7 ± 0.2 c	14.5 ± 0.1 c	15.0 ± 0.1 c	16.1 ± 0.2 c

Table S9a. Cumulative dry biomass (g m⁻²) in the pot experiment main and additional^b parts. There was a significant difference between the biomass dry weights of the control and AN70 treatments of the main and additional experiments. Therefore, biomass data were converted to the % increase over the control biomass of the AN70 treated grass biomass, for which there were no significant differences.

Experiment	Treatment	Day 31	Day 59	Day 94	Day 129	Day 164	Day 199	Day 234	Day 269	Day 304	Day 340	Day 364
Main	Control	63 ± 7	105 ± 9	147 ± 12	180 ± 12	225 ± 14	269 ± 14	353 ± 17	458 ± 11	508 ± 11	537 ± 13	636 ± 18
Additional	Control	94 ± 2	151 ± 5	207 ± 6	248 ± 6	284 ± 8	343 ± 8	406 ± 11	510 ± 8	585 ± 12	619 ± 13	731 ± 19
Main	AN 35	101 ± 3	155 ± 5	207 ± 9	243 ± 10	283 ± 11	327 ± 14	403 ± 16	498 ± 15	545 ± 16	573 ± 16	685 ± 18
Main	AN 70	116 ± 4	195 ± 10	259 ± 11	300 ± 12	343 ± 13	384 ± 14	459 ± 21	559 ± 21	609 ± 22	637 ± 22	729 ± 25
Additional	AN70	181 ± 8	274 ± 11	334 ± 10	382 ± 9	417 ± 11	472 ± 11	540 ± 14	644 ± 18	707 ± 18	739 ± 19	835 ± 23
Additional	AN140	190 ± 16	353 ± 10	427 ± 6	469 ± 7	507 ± 7	561 ± 7	622 ± 8	725 ± 13	781 ± 9	817 ± 10	924 ± 18
Additional	AN 200	200 ± 11	424 ± 15	534 ± 13	581 ± 14	615 ± 15	660 ± 29	717 ± 25	817 ± 29	880 ± 29	912 ± 31	1019 ± 28
Main	Clover	123 ± 4	241 ± 20	358 ± 16	416 ± 15	464 ± 16	511 ± 18	585 ± 25	693 ± 30	747 ± 29	778 ± 30	889 ± 38
Main	Alder	74 ± 1	168 ± 10	283 ± 17	347 ± 18	411 ± 18	482 ± 16	575 ± 17	689 ± 22	741 ± 29	776 ± 23	895 ± 23
Main	Gunnera	55 ± 1	108 ± 9	214 ± 22	342 ± 17	438 ± 20	522 ± 20	647 ± 24	801 ± 26	860 ± 25	900 ± 25	1067 ± 34
Main	Gorse	87 ± 4	157 ± 5	240 ± 4	290 ± 2	339 ± 4	402 ± 5	511 ± 6	635 ± 10	693 ± 14	728 ± 14	855 ± 18

^b See explanation in Table S5

Table S9b. Pot experiment biomass (% increase over control) of the cumulative biomass dry weights. P values of t-tests showing that there were no significant differences between the % increase in biomass over the control of the AN70 treatment for the main and the additional^b experiments are shown in the final row.

Experiment	Treatment	Day 31	Day 59	Day 94	Day 129	Day 164	Day 199	Day 234	Day 269	Day 304	Day 340	Day 364
Main	AN 35	61 ± 5	47 ± 4	41 ± 5	35 ± 5	26 ± 5	22 ± 5	14 ± 4	9 ± 3	7 ± 3	7 ± 3	8 ± 3
Main	AN 70	85 ± 6	85 ± 9	77 ± 7	67 ± 6	52 ± 5	43 ± 5	30 ± 5	22 ± 4	20 ± 4	19 ± 4	15 ± 3
Additional	AN70	91 ± 7	81 ± 6	62 ± 4	54 ± 3	47 ± 3	37 ± 3	33 ± 3	26 ± 3	21 ± 3	19 ± 3	14 ± 3
Additional	AN140	101 ± 15	133 ± 6	107 ± 3	89 ± 3	79 ± 2	64 ± 2	53 ± 2	42 ± 2	34 ± 1	32 ± 1	26 ± 2
Additional	AN 200	112 ± 11	181 ± 9	159 ± 6	134 ± 5	117 ± 5	93 ± 7	77 ± 5	60 ± 5	50 ± 4	47 ± 4	39 ± 3
Main	Clover	97 ± 6	129 ± 17	144 ± 10	132 ± 8	106 ± 6	90 ± 6	66 ± 6	51 ± 6	47 ± 5	45 ± 5	40 ± 5
Main	Alder	18 ± 2	59 ± 9	93 ± 10	94 ± 9	83 ± 7	79 ± 5	63 ± 4	50 ± 4	46 ± 4	45 ± 4	41 ± 3
Main	Gunnera	-13 ± 2	2 ± 8	46 ± 14	90 ± 9	95 ± 8	94 ± 7	83 ± 6	75 ± 5	69 ± 4	68 ± 4	68 ± 5
Main	Gorse	38 ± 5	49 ± 4	64 ± 3	62 ± 1	51 ± 1	50 ± 2	45 ± 2	39 ± 2	36 ± 2	36 ± 2	35 ± 3
Both AN70	P value	0.518	0.740	0.112	0.090	0.432	0.378	0.643	0.426	0.832	0.887	0.930

^b See explanation in Table S5

Table S10a Pot experiment soil NO₃⁻ N concentrations (mg L⁻¹ soil solution). Transformed by log 10 (data point + 1) to improve heterogeneity and normality. Taken in the first 95 days after N additions of 200 kg N ha⁻¹ equivalent within leaf tissue (clover, alder, gunnera or gorse) or NH₄NO₃ (AN) in soil solution, means ± SEM (*n* = 5). Untransformed data in Fig 4a

	Day 1	Day 3	Day 5	Day 9	Day 13	Day 18	Day 25	Day 32	Day 39	Day 53	Day 67	Day 82	Day 95
Control	1.3 ± 0.1	1.3 ± 0.0	1.4 ± 0.0	0.3 ± 0.1	0.3 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Clover	1.3 ± 0.0	1.5 ± 0.0	1.7 ± 0.0	1.9 ± 0.1	1.6 ± 0.1	1.8 ± 0.1	1.5 ± 0.1	2.1 ± 0.1	1.8 ± 0.1	1.0 ± 0.4	0.3 ± 0.2	0.0 ± 0.0	0.0 ± 0.0
Alder	1.2 ± 0.1	1.2 ± 0.1	1.2 ± 0.0	0.6 ± 0.1	0.5 ± 0.1	0.4 ± 0.1	0.1 ± 0.1	0.3 ± 0.1	1.0 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Gorse	1.1 ± 0.1	1.3 ± 0.0	1.4 ± 0.0	1.1 ± 0.2	1.0 ± 0.1	0.7 ± 0.1	0.1 ± 0.1	0.1 ± 0.0	0.4 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Gunnera	1.2 ± 0.0	1.2 ± 0.0	1.2 ± 0.0	0.2 ± 0.1	0.2 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
AN35	1.7 ± 0.1	1.9 ± 0.0	2.0 ± 0.0	1.7 ± 0.0	1.6 ± 0.1	1.4 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	0.6 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
AN70	1.9 ± 0.1	2.1 ± 0.0	2.2 ± 0.0	2.1 ± 0.1	2.0 ± 0.1	2.1 ± 0.1	1.2 ± 0.1	0.3 ± 0.1	1.0 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

Table S10b P values between treatments of the Pot Experiment soil NO₃⁻ N concentrations (Fig 4a; Table S10a), determined by a two way ANOVA, with treatments and sampling time as the fixed factors.

Treatment	Control	Clover	Alder	Gunnera	Gorse	AN70
Control	-					
Clover	< .001	-				
Alder	.190	< .001	-			
Gunnera	.959	< .001	.025	-		
Gorse	.011	< .001	.858	.001	-	
AN35	< .001	< .001	< .001	< .001		
AN70	< .001	.138	< .001	< .001	< .001	-

Table S10c P values between sampling times of the Pot Experiment soil NO₃⁻ N concentrations (Fig 4a; Table S10a), determined by a two way ANOVA, with treatments and sampling time as the fixed factors.

[illegible]

Table S11a. Pot experiment TDN (mg N L⁻¹) after addition of 200 kg N ha⁻¹ within clover, alder, and gunnera and NH₄NO₃ at 35 and 70 kg N ha⁻¹ to day 180. Letters denote difference at P < 0.05 ascertained by ANOVA on transformed data in S101b. Means ± SEM (*n* = 5).

Day	1	3	5	9	13	18	25	32	39	53	67	95	124	151	180
Control	21.1 ± 3.0 a	24.6 ± 4.3 a	24.6 ± 1.5 a	23.0 ± 4.1 a	1.9 ± 0.7 a	1.5 ± 0.1 a	1.9 ± 0.2 a	1.4 ± 0.2 a	1.7 ± 0.1 a	0.8 ± 0.1 a	1.3 ± 0.1 a	1.8 ± 0.1 a	1.7 ± 0.1a	1.8 ± 0.1a	1.8 ± 0.1a
Clover	24.5 ± 5.8 a	43.0 ± 8.7 a	54.6 ± 5.6 b	123.5 ± 33.8 b	48.3 ± 12.3 b	122.9 ± 18.3 b	100.8 ± 23.9 b	141.1 ± 24.9 b	134.0 ± 26.9 b	18.6 ± 8.0 b	4.0 ± 0.7 c	3.2 ± 0.3 b	2.4 ± 0.2b	2.5 ± 0.2a	2.0 ± 0.1a
Alder	14.0 ± 2.3 a	13.3 ± 1.6 a	14.3 ± 1.1 a	12.0 ± 1.1 a	4.1 ± 0.8 a	3.2 ± 1.0 a	2.6 ± 0.2 a	3.5 ± 0.7 a	9.9 ± 1.6 a	1.4 ± 0.2 a	2.4 ± 0.2 b	2.8 ± 0.2 ab	2.3 ± 0.2a	2.4 ± 0.3a	1.8 ± 0.1 a
Gunnera	18.0 ± 1.4 a	16.3 ± 1.0 a	17.7 ± 2.7 a	14.2 ± 6.2 a	1.8 ± 0.5 a	2.2 ± 0.4 a	1.5 ± 0.3 a	1.7 ± 0.1 a	1.2 ± 0.1 a	0.7 ± 0.1 a	1.8 ± 0.2 a	3.2 ± 0.2 b	3.6 ± 1.0b	2.7 ± 0.5a	2.5 ± 0.7b
Gorse	14.7 ± 3.1 a	19.4 ± 2.1 a	23.6 ± 5.7 a	35.0 ± 5.9 a	12.0 ± 3.8 ab	7.9 ± 2.0 a	4.4 ± 0.1 a	4.1 ± 0.5 a	5.5 ± 1.0 a	3.2 ± 0.4 a	3.8 ± 0.3 bc	5.5 ± 0.5 c	4.4 ± 0.4b	4.7 ± 0.1b	3.8 ± 0.3b
AN 35	89.2 ± 10.2 b	93.8 ± 7.4 b	120.4 ± 12.8 c	123.0 ± 12.8 b	57.7 ± 8.7 c	36.6 ± 4.1 b	1.2 ± 0.3 a	2.1 ± 0.3 a	4.6 ± 0.9 a	0.8 ± 0.1 a	1.8 ± 0.1 a	2.0 ± 0.1 ab	1.8 ± 0.1a	1.8 ± 0.1a	1.6 ± 0.1a
AN 70	98.9 ± 17.7 b	107.1 ± 18.1 b	155.8 ± 9.6 d	129.0 ± 21.0 b	84.2 ± 18.2 c	141.4 ± 10.8 b	34.4 ± 3.1 a	3.1 ± 0.8 a	13.9 ± 2.9 a	0.8 ± 0.1 a	1.8 ± 0.1 a	2.2 ± 0.2 ab	2.0 ± 0.2a	1.9 ± 0.1a	1.6 ± 0.1a

Table S11b Pot experiment TDN (mg L⁻¹) Data as above transformed by log 10 (data point + 1) to improve heterogeneity and normality before ANOVA.

Day	1	3	5	9	13	18	25	32	39	53	67	95	124	151	180
Control	1.3 ± 0.1	1.4 ± 0.1	1.4 ± 0.0	1.3 ± 0.1	0.4 ± 0.1	0.4 ± 0.0	0.5 ± 0.0	0.4 ± 0.0	0.4 ± 0.0	0.3 ± 0.0	0.4 ± 0.0	0.4 ± 0.0	0.4 ± 0.0	0.4 ± 0.0	0.4 ± 0.0
Clover	1.4 ± 0.1	1.6 ± 0.1	1.7 ± 0.0	2.0 ± 0.1	1.7 ± 0.1	2.1 ± 0.1	2.0 ± 0.1	2.1 ± 0.1	2.1 ± 0.1	1.0 ± 0.1	0.7 ± 0.1	0.6 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0
Alder	1.2 ± 0.1	1.1 ± 0.1	1.2 ± 0.0	1.1 ± 0.0	0.7 ± 0.1	0.5 ± 0.1	0.5 ± 0.0	0.6 ± 0.1	1.0 ± 0.1	0.4 ± 0.0	0.5 ± 0.0	0.6 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.4 ± 0.0
Gorse	1.2 ± 0.1	1.3 ± 0.0	1.3 ± 0.1	1.5 ± 0.1	1.0 ± 0.1	0.9 ± 0.1	0.7 ± 0.0	0.7 ± 0.0	0.8 ± 0.1	0.6 ± 0.0	0.7 ± 0.0	0.8 ± 0.0	0.7 ± 0.1	0.8 ± 0.0	0.7 ± 0.1
Gunnera	1.3 ± 0.0	1.2 ± 0.0	1.3 ± 0.1	1.1 ± 0.1	0.4 ± 0.1	0.5 ± 0.0	0.4 ± 0.1	0.4 ± 0.0	0.3 ± 0.0	0.2 ± 0.0	0.4 ± 0.0	0.6 ± 0.0	0.7 ± 0.0	0.6 ± 0.0	0.5 ± 0.0
AN 35	1.9 ± 0.0	2.0 ± 0.0	2.1 ± 0.0	2.1 ± 0.0	1.7 ± 0.1	1.6 ± 0.1	0.3 ± 0.1	0.5 ± 0.0	0.7 ± 0.1	0.3 ± 0.0	0.4 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.4 ± 0.0	0.4 ± 0.0
AN 70	2.0 ± 0.1	2.0 ± 0.1	2.2 ± 0.0	2.1 ± 0.1	1.9 ± 0.1	2.1 ± 0.0	1.5 ± 0.0	0.6 ± 0.1	1.1 ± 0.1	0.3 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.4 ± 0.0

Table S11c P values between treatments of the Pot Experiment TDN, determined by a two way ANOVA of the tranformed data (Table S11b), with treatments and sampling time as the fixed factors.

Treatment	Control	Clover	Alder	Gunnera	Gorse	AN35	AN70
Control	-						
Clover	< .001	-					
Alder	.678	< .001	-				
Gunnera	1.000	< .001	.736	-			
Gorse	< .001	< .001	.006	< .001	-		
AN35	< .001	< .001	< .001	< .001	.161	-	
AN70	< .001	.017	< .001	< .001	< .001	.006	-

Table S11d P values between sampling times of the Pot Experiment TDN, determined by a two way ANOVA of the tranformed data (Table S11b), with treatments and sampling time as the fixed factors.

Sampling time (day)	1	3	5	9	13	18	25	32	39	53	67	95	124	151	180	
1	-															
3	1.000	-														
5	.002	.551	-													
9	.096	1.000	1.000	-												
13	< .001	< .001	< .001	< .001	-											
18	< .001	< .001	< .001	< .001	1.000	-										
25	< .001	< .001	< .001	< .001	< .001	< .001	-									
32	< .001	< .001	< .001	< .001	< .001	< .001	.008	-								
39	< .001	< .001	< .001	< .001	< .001	< .001	1.000	< .001	-							
53	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	-						
67	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	1.000	-				
95	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	.221	.010	-			
124	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	1.000	1.000	.641	-		
151	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	1.000	1.000	.001	1.000	-	
180	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	1.000	1.000	< .001	1.000	.000	-

Table S12a Phenolic compounds in soil solution of the pot experiment (mg L⁻¹) after addition of 200 kg N ha⁻¹ within clover, alder, gunnera and gorse, and NH₄NO₃ at 35 and 70 kg N ha⁻¹. Means ± SEM (*n* = 5). Letters denote differences between treatments at *P* < 0.05

Day	5	25	67	95	151	206	263	318
No addition	1.7 ± 0.2 ab	0.7 ± 0.4	0.9 ± 0.1 abc	1.9 ± 0.7 ab	1.4 ± 0.3 a	1.9 ± 0.2 ab	1.5 ± 0.2 a	1.3 ± 0.3 bc
Clover	3.1 ± 0.6 ab	3.0 ± 0.5	1.1 ± 0.3 bc	2.0 ± 0.7 ab	2.5 ± 0.3 a	1.9 ± 0.3 ab	2.6 ± 0.4 a	0.9 ± 0.2 abc
Alder	4.1 ± 0.5bc	1.2 ± 0.4	1.3 ± 0.1 c	2.6 ± 0.8 ab	2.1 ± 0.4 a	2.2 ± 0.4 ab	1.6 ± 0.4 a	2.0 ± 0.5 bc
Gunnera	1.9 ± 0.4 ab	1.9 ± 0.5	1.5 ± 0.3 cd	2.5 ± 0.7 ab	3.1 ± 0.6 ab	2.6 ± 0.3 ab	2.3 ± 0.2 a	2.0 ± 0.4 c
Gorse	1.7 ± 0.5 a	2.9 ± 0.6	2.4 ± 0.2 d	3.7 ± 0.6 b	5.8 ± 0.9 b	3.1 ± 0.6 b	4.7 ± 0.2 b	1.8 ± 0.2 bc
AN 35	4.4 ± 1.0 bc	2.5 ± 2.0	0.5 ± 0.1 a	0.4 ± 0.1 a	1.8 ± 0.1 a	1.3 ± 0.2 a	1.7 ± 0.1 a	0.2 ± 0.2 a
AN 70	7.1 ± 1.1 c	1.7 ± 0.7	0.6 ± 0.1 ab	0.9 ± 0.2 a	1.5 ± 0.4 ab	1.6 ± 0.2 ab	1.5 ± 0.3 a	0.8 ± 0.1 ab

Table S12b P values between treatments of the Pot Experiment phenolic compounds (Table S12a). determined by a two way ANOVA, with treatments and sampling time as the fixed factors.

Treatment	Control	Clover	Alder	Gunnera	Gorse	AN35	AN70
Control	-						
Clover	.027	-					
Alder	.036	1.000	-				
Gunnera	.003	.977	.956	-			
Gorse	< .001	.004	.003	.036	-		
AN35	.992	.005	.006	.001	< .001	-	
AN70	.882	.315	.378	.062	< .001	.487	-

Table S12c P values between sampling times of the Pot Experiment phenolic compounds (Table S12a) determined by a two way ANOVA, with treatments and sampling time as the fixed factors.

Sampling time (day)	5	25	67	95	151	206	263	318
5	-							
25	.005	-						
67	< .001	.596	-					
95	.005	1.000	.120	-				
151	.976	.397	< .001	.372	-			
206	.061	1.000	< .001	1.000	1.000	-		
263	.050	1.000	< .001	1.000	1.000	1.000	-	
318	< .001	1.000	1.000	.769	< .001	< .001	< .001	-

Table S13a P values between treatments of the field experiment Year 1 soil NO₃⁻ N concentrations (Fig 4b), determined by a two way ANOVA, with treatments and sampling time as the fixed factors.

Treatment	Control	AN100	AN200	Ald F Inc	Ald F M	Ald D Inc	Ald D M	Gorse D M	Gun D M
Control	-								
AN100	.982	-							
AN200	< .001	< .001	-						
Ald F Inc	1.00	.744	< .001	-					
Ald F M	1.00	.702	< .001	1.00	-				
Ald D Inc	1.00	.863	< .001	1.00	1.00	-			
Ald D M	1.00	1.000	< .001	1.00	1.00	1.00	-		
Gorse D M	1.00	1.000	< .001	1.00	1.00	1.00	1.00	-	
Gun D M	1.00	.607	< .001	1.00	1.00	1.00	1.00	1.00	-

Table S13b P values between sampling times of the field experiment Year 1 soil NO₃⁻ N concentrations (Fig 4b), determined by a two way ANOVA, with treatments and sampling time as the fixed factors.

Sampling time (day)	1	3	7	13	20	27	41	69
1	-							
2	1.000	-						
7	.066	.001	-					
13	.052	.001	1.000	-				
20	.269	.107	1.000	1.000	-			
27	.021	< .001	< .001	< .001	.296	-		
41	.044	.001	1.000	1.000	1.000	< .001	-	
69	.028	< .001	< .001	< .001	.783	< .001	.001	-

Table S14a Field Experiment Year 2 Soil NO₃⁻ N (mg kg⁻¹ dry soil) concentrations transformed by log 10 (data point + 1) to improve heterogeneity and normality. Taken in the first 70 days after N additions of 200 kg N ha⁻¹ equivalent within leaf tissue or AN. Concentrations in dry soil at 0 to 100 mm depth, means ± SEM (*n* = 4). The treatments refer to those added in the previous year only, or in both the previous and current years. Untransformed data in Fig 4c.

Day	1	3	7	13	20	27	41	69
Control	0.9 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.2 ± 0.0	1.2 ± 0.1	0.9 ± 0.1	0.9 ± 0.1	0.8 ± 0.1
AN 100 + 100	1.8 ± 0.1	1.6 ± 0.1	1.6 ± 0.1	1.9 ± 0.0	1.9 ± 0.1	1.6 ± 0.1	0.7 ± 0.3	0.9 ± 0.1
AN 200 + 0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.1	1.2 ± 0.1	1.3 ± 0.1	0.9 ± 0.1	0.8 ± 0.1	0.6 ± 0.1
AN 200 + 200	2.1 ± 0.1	2.1 ± 0.1	1.8 ± 0.2	1.9 ± 0.2	2.0 ± 0.1	1.3 ± 0.5	1.4 ± 0.2	1.1 ± 0.2
Ald + 0	1.0 ± 0.0	1.1 ± 0.1	1.0 ± 0.0	1.2 ± 0.1	1.3 ± 0.0	0.9 ± 0.1	0.8 ± 0.1	0.8 ± 0.1
Ald + Ald	0.9 ± 0.1	0.8 ± 0.1	0.9 ± 0.1	0.9 ± 0.1	0.8 ± 0.1	0.7 ± 0.1	1.0 ± 0.1	0.6 ± 0.1
Gun + 0	1.1 ± 0.0	1.2 ± 0.1	0.9 ± 0.1	0.9 ± 0.3	1.3 ± 0.0	0.8 ± 0.1	0.9 ± 0.1	0.8 ± 0.1
Gun + Gun	0.9 ± 0.1	1.1 ± 0.1	0.9 ± 0.1	0.5 ± 0.3	0.3 ± 0.2	0.9 ± 0.0	1.0 ± 0.0	0.7 ± 0.1

Table S14b P values between treatments of the field experiment Year 2 soil NO₃⁻ concentrations (Fig 4c. Table 14a), determined by a two way ANOVA, with treatments and sampling time as the fixed factors.

Treatment	Control	AN 100 + 100	AN 200 + 0	AN 200 + 200	Ald + 0	Ald + Ald	Gun + 0	Gun + Gun
Control	-							
AN 100 + 100	< .001	-						
AN 200 + 0	1.000	< .001	-					
AN 200 + 200	< .001	.132	< .001	-				
Ald + 0	1.000	< .001	.999	< .001	-			
Ald + Ald	.342	< .001	.552	< .001	.257	-		
Gun + 0	1.000	< .001	1.000	< .001	1.000	.359	-	
Gun + Gun	.273	< .001	.464	< .001	.201	1.000	.273	-

Table SW14c P values between sampling times of the field experiment Year 2 soil NO₃⁻ concentrations (Fig 4c, Table 14a), determined by a two way ANOVA, with treatments and sampling time as the fixed factors.

Sampling time (day)	1	3	7	13	20	27	41	69
1	-							
2	1.000	-						
7	1.000	.458	-					
13	1.000	1.000	1.000	-				
20	1.000	1.000	1.000	1.000	-			
27	.162	.224	1.000	1.000	.209	-		
41	.001	< .001	.008	.019	< .001	1.000		
69	< .001	< .001	< .001	.002	< .001	.768	.924	-

Table S15a Field experiment year 1. TDN (mg kg⁻¹ dry soil) after treatments as in Table S7. Means ± SEM (*n* = 4) Letters denote differences between treatments at *P* < 0.05. There were no significant difference after day 41.

Day	1	3	7	13	27	41	55	69	97	209 (0 -150 mm)	209 (150 – 300 mm)
Control	30.3 ± 3.0 a	34.1 ± 1.9 a	36.5 ± 1.7	30.6 ± 2.3 a	25.9 ± 1.5 a	16.3 ± 1.9 a	18.8 ± 0.9	14.1 ± 1.5	18.3 ± 0.7	32.6 ± 0.3	30.3 ± 1.9
AN100	112.2 ± 34.5 b	81.9 ± 7.5 a	104.3 ± 16.2	105.9 ± 23.9 b	34.6 ± 3.6 a	18.5 ± 0.7 a	21.5 ± 1.4	15.8 ± 0.8	17.5 ± 1.9	30.6 ± 0.8	31.5 ± 3.6
AN200	198.8 ± 31.4 c	210.1 ± 63.9 b	293.3 ± 42.4	172.8 ± 3.8 c	73.1 ± 21.7 b	20.6 ± 1.4 a	20.2 ± 2.9	14.8 ± 1.9	25.6 ± 8.0	30.9 ± 2.2	33.3 ± 4.4
Ald F Inc	34.2 ± 3.2 ab	32.8 ± 2.7 a	33.6 ± 3.0	33.7 ± 1.9 a	34.6 ± 3.2 a	18.8 ± 1.3 a	20.9 ± 1.5	17.5 ± 0.9	20.5 ± 1.6	30.3 ± 1.8	31.5 ± 0.3
Ald F M	34.5 ± 3.8 ab	34.8 ± 2.8 a	35.7 ± 3.7	29.5 ± 2.4 a	26.6 ± 1.2 a	19.6 ± 2.3 a	21.5 ± 1.9	21.5 ± 3.0	18.6 ± 1.2	32.7 ± 2.7	32.3 ± 1.7
Ald D Inc	32.2 ± 13.2 a	35.2 ± 8.2 a	45.2 ± 7.5	39.5 ± 4.5 a	28.0 ± 2.4 a	34.5 ± 3.9 b	25.8 ± 4.0	19.3 ± 0.5	22.6 ± 1.7	29.8 ± 2.4	29.8 ± 1.8
Ald D M	29.4 ± 11.5 a	44.5 ± 6.2 a	45.1 ± 6.7	44.1 ± 4.0 a	24.6 ± 1.4 a	25.5 ± 3.1 b	22.2 ± 1.6	18.3 ± 3.0	22.6 ± 1.0	29.5 ± 1.0	26.7 ± 4.7
Gorse D M	35.8 ± 2.1 ab	41.9 ± 3.7 a	30.5 ± 3.5	37.9 ± 4.2 a	28.7 ± 4.1 a	N/A	22.8 ± 2.8	17.9 ± 1.3	19.2 ± 0.8	26.7 ± 1.6	32.8 ± 1.5
Gun D M	43.5 ± 6.7 ab	34.6 ± 1.2 a	27.8 ± 2.31	28.2 ± 2.1 a	24.1 ± 1.2 a	22.2 ± 3.13 a	13.5 ± 4.56	14.7 ± 2.2	19.3 ± 1.4	28.6 ± 1.9	29.7 ± 1.4

Table S15b Field experiment year 2. TDN (mg kg⁻¹ dry soil) after treatments as in Table S7. Means ± SEM (*n* = 4) Letters denote differences between treatments at *P* < 0.05. There were no significant difference after day 41.

Day	1	3	7	13	20	27	41	69	97	116
Control	16.6 ± 1.5 a	16.2 ± 1.6 a	15.6 ± 1.7 a	20.3 ± 1.2 a	20.5 ± 2.5 a	14.7 ± 2.6 a	18.2 ± 1.7 a	21.4 ± 1.4	29.7 ± 2.7	31.4 ± 2.5
AN 100 + 100	124.5 ± 16.5 bc	73.4 ± 3.1 b	53.8 ± 17.8 ab	74.8 ± 9.6 b	84.1 ± 15.6 ab	50.5 ± 12.9 a	22.7 ± 1.9 a	28.3 ± 3.9	41.1 ± 3.2	45.9 ± 4.6
AN 200 + 0	23.3 ± 0.6 a	14.4 ± 2.5 a	13.5 ± 1.3 a	19.9 ± 3.7 a	27.1 ± 2.8 a	17.8 ± 2.0 a	16.1 ± 0.9 a	21.6 ± 1.9	28.5 ± 4.2	30.6 ± 6.6
AN 200 + 200	166.3 ± 19.2 c	125.1 ± 19.4 c	76.1 ± 23.5 b	86.2 ± 18.9 b	126.8 ± 40.3 b	127.7 ± 41.4 b	46.6 ± 10.6 b	42.2 ± 13.1	81.3 ± 18.4	80.7 ± 23.6
Ald + 0	19.5 ± 2.4 a	18.3 ± 2.2 a	12.9 ± 2.5 a	18.6 ± 2.0 a	24.0 ± 1.3 a	19.0 ± 1.0 a	20.0 ± 4.0 a	25.1 ± 3.1	30.9 ± 1.7	33.3 ± 2.3
Ald + Ald	19.4 ± 1.0 a	16.1 ± 1.4 a	14.4 ± 1.9 a	16.8 ± 1.7 a	22.3 ± 4.2 a	15.3 ± 2.1 a	25.7 ± 1.8 ab	22.3 ± 5.1	31.4 ± 5.9	37.1 ± 3.9
Gun + 0	35.9 ± 17.1 ab	16.6 ± 2.9 a	13.8 ± 1.5 a	20.3 ± 1.3 a	22.2 ± 0.8 a	18.0 ± 1.2 a	17.3 ± 1.1 a	18.8 ± 0.9	26.8 ± 1.6	28.4 ± 1.4
Gun + Gun	77.1 ± 52.5 abc	18.6 ± 1.3 a	12.9 ± 2.3 a	19.2 ± 1.1 a	15.1 ± 3.0 a	24.1 ± 3.3 a	27.1 ± 2.6 ab	22.1 ± 1.9	28.7 ± 4.1	44.5 ± 9.3

Table S16 pH Field experiment pre-Year 2 (March) given as single values from NRM laboratories (Cawood Sciencific, Bracknell, UK). Field experiment post-Year 2 (September). Treatments as in Table S7. Means ± SE, *n* = 4). Letters denote differences between treatments at *P* < 0.05.

Treatment	Pre Year 2 exp	Post Year 2 exp
Control	6.0	6.1 ± 0.1 ab
AN 100 + 100	5.9	6.5 ± 0.2 ab
AN 200 + 0	5.9	6.0 ± 0.3 ab
AN 200 + 200	5.9	5.7 ± 0.1 a
Ald + 0	6.0	6.1 ± 0.1 ab
Ald + Ald	6.0	6.3 ± 0.1 ab
Gun + 0	6.3	6.8 ± 0.2 b
Gun + Gun	6.3	6.7 ± 0.2 b

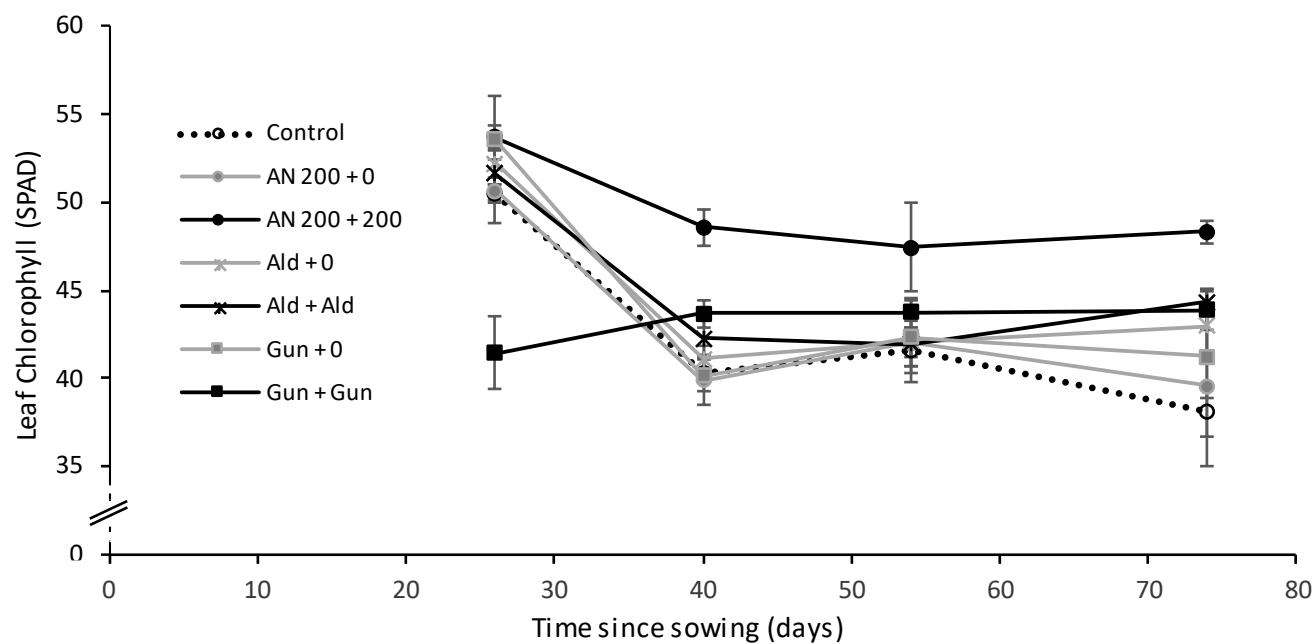


Fig S1 Field experiment year 2. Leaf chlorophyll content as measured by SPAD meter. Readings taken from the highest fully expanded leaf of 10 randomly selected wheat plants within plots fertilised with 200 kg N ha⁻¹ supplied within alder, gunnera or NH₄NO₃ (AN) in the year previous to sampling only (grey lines) or both the previous and the present years (black lines). (Means + SEM, $n = 4$)