REPORT III

RESULTS FROM THE SOURHOPE FIELD EXPERIMENT: 1999-2001

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January 2002

CONTENTS

1. INTRODUCTION

The NERC Soil Biodiversity Thematic Programme is centred upon the intensive study of a large field experiment located at the Macaulay Land Use Research Institute's farm at Sourhope in the Scottish Borders. A full description of the site, the rationale for the main field experiment and experimental design, methods and management can be found in the Baseline Data Survey dated November 1998.

At the outset of the experiment, a broad scale of monitoring was prescribed in order to provide research groups with a general context in which to view their more detailed studies. The presentation of a large number of figures and tables closely follows the procedure adopted in Report II, with the twin aims of enabling groups to more easily recognise links with their own data as well as facilitating comparisons between years. The types and dates of measurements are listed in Table 1.

Management of the site was impacted by two unrelated events in 2001:

a) Use of the Sourhope field site was affected by the imposition of Government restrictions following the outbreak of Foot and Mouth Disease (FMD) in the UK during February 2001 (Table 2). No visitors were allowed to visit the site between February and the end of May. During this period work was undertaken by the Officer(s) in Charge on behalf of research groups in accordance with an agreed timetable. Thereafter researchers were able to resume their own sampling subject to their visits complying with a protocol laid out by the Macaulay Land Use Research Institute vet in Aberdeen and strictly monitored by the Officer in Charge at Sourhope.

Key management activities on the Site were relatively unaffected by FMD. As a result liming, nitrogen application, pH measurements, biomass collections, vegetation cutting and Point Analysis were undertaken in accordance with the agreed 2001 Site Management Plan. Although the first biocide application in May was missed, the following four applications were successfully completed.

b) The officer in charge at the site changed, following the departure of Sarah Buckland in May 2001.

2. RESULTS

2.1 Automatic Weather Station. 2001 headline weather data collected from the site were generally unremarkable (Table 3). Following the previous particularly wet year, rainfall was close to the long term annual average. Total annual radiation showed little change, whilst average temperatures were slightly reduced and average soil moisture content was somewhat raised compared to previous years

2.2 Above-ground biomass. Amongst the treatments there was a consistent hierarchy of biomass estimates throughout the sampling period and all treatments yielded peak biomass production in July or August (Fig 1). It is, however, noteworthy that there was a substantial increase in biomass estimates in 2001 compared to the previous years (Fig 2a). It is suggested that this is likely to result from a combination of a change in personnel and the switch from manual cutting to the use of mechanical shears in 2001. All treatment measures were therefore normalised against C1 in each year (Fig 2b) to identify a continuation of the positive impact upon productivity of nitrogen and, to a lesser extent, lime. As in the previous year, the most effective promotion of above-ground biomass was apparent in the nitrogen plus lime treatment.

In separate analyses biomass dry weights were ln-transformed before performing ANOVA's which reveal significant differences (Table 4) between improved (N and/or L added) and non-improved plots, a significant interaction between treatment and year (Table 5) but no significant differences between blocks ($F=0.76$, $df=4,115$, $p>0.05$).

2.3 Soil pH. Soil samples collected from the upper 5cm of the soil profile show that the addition of lime has continued to raise soil pH to an average, in October 2001, of 6.19 in the limed plots and 6.38 in the N&L plots, whilst the addition of nitrogen alone has also raised soil pH albeit it to a lesser extent (Fig 3). Mean soil pH in the control plots has not changed significantly since the baseline measures were collected in August 1998.

2.4 Botanical composition. The protocol for the Point Analysis survey in July 2001 mirrored that used in July 2000 and, on each occasion, Sarah Buckland was one of the two surveyors who were each responsible for approximately 50% of the total number of quadrats surveyed. There was no statistically significant difference between the results recorded by each surveyor in 2001 (Genstat 5, General blocked ANOVA F=1.90; df = 2, 1, 26; p = 0.18NS). It is perhaps of some significance, therefore, that the total number of hits in the 2001 survey was 58% higher than the total number of hits in the 2000 survey and this is apparent across all treatments. This suggests that the sward is becoming more dense perhaps resulting from the removal of grazing stock in 1998.

There were clear treatment differences in the most frequently encountered species in 2001 (Fig 4). Although the identities of these species did not vary significantly when compared to the same treatments in the previous year, absolute values of relative abundance, measured as the number of “hits” per species as a percentage of the total number of “hits” within each treatment, revealed a number of large changes between 2001 and 2000 (Table 6). In particular *Agrostis capillaris*, which was the most frequently encountered species in every treatemnt in 2000, showed a decline across all treatments in 2001 with the result that it only remained the most abundant species in the Control 1 and Limed plots. In contract both *Festuca* species (*ovina* and *rubra*) increased across all treatments and were most frequently encountered within the Nitrogen and Biocide (*Festuca ovina*) and Nitrogen & Lime (*Festuca rubra*) plots. Species associated with improved grassland (*Festuca rubra* and *Poa pratensis*) were most apparent in the fertilised plots (particularly those treated with both Nitrogen and Lime) whilst species associated with less fertile pastures, such as *Anthoxanthum odoratum* and *Nardus stricta* were more apparent within the untreated Control plots (Fig 4).

A total of 24 separate species were identified in each of the unimproved treatments (Control and Biocide) whilst only 18 separate species were found within the Nitrogen & Lime plots suggesting that plant diversity may be starting to decline within the most improved plots (Table 6).

The Point Analysis data have been subjected to Principal Components Analysis (PCA, Genstat 5) (Fig 5) in order to examine the degree of association between samples. There is no statistical weighting applied to the less common species as the intention is to focus on any broad shifts among the dominant species. The analysis largely separates those plots treated with nitrogen and/or lime from the control and biocide plots. The vegetation within these latter unimproved plots tends to be rather more uniform and is associated, in particular, with the presence of *Agrostis vinealis*, *Rhytidiadelphus squarrosus* (and other bryophytes), *Nardus stricta* and *Anthoxanthum odoratum*. The improved plots (ie those treated with Nitrogen and/or Lime) often account for the most extreme points (Fig 5a) and an increase in the frequency of contact with *Festuca rubra* within the limed plots is particularly apparent. Species closely aligned with *F. rubra* include *Poa pratensis*, *Poa trivialis* and *Holcus mollis.*

Further evidence for the direction of change initiated by the main plot treatments can be seen when the number of hits per plot for the major vegetation species are correlated against estimates of the above-ground biomass obtained for each plot during the summer 2001 cuts (Fig 6). The relative abundance of *Festuca rubra* and *Poa pratensis* are positively correlated with biomass, whilst *Anthoxanthum odoratum*, *Nardus stricta*, *Rhytidiadelphus squarrosus* (plus other bryophytes) and *Agrostis vinealis* decline in relative abundance as biomass increases. There is a significant increase in the frequency with which litter is encountered in those plots treated with nitrogen and/or lime, reflecting a faster rate of vegetation turnover as soil fertility increases.

3. SITE HETEROGENEITY

3.1 Variation in surface soil pH and plant community composition. It was noted in the year 2000 report that columns E and F, on the right-hand side of the site facing up the slope, contained more acidic plots than columns on the left-hand side of the slope. Although this effect is probably exaggerated by the fact that 60% of the plots in these columns are either Controls or treated with Biocide, there is support for an underlying spatial heterogeneity across the experimental site in the comparatively low pH measures recorded within the Nitrogen and/or Lime improved plots in theses columns (Fig 7).

3.2 Variation in vegetation Biomass. Total biomass values for each plot are shown in Fig 8. In 2001 outlying plots contain the lowest biomass within all treatments (Control 1 plot 5A; Control 2 plot 1D; Nitrogen plot 2A; Lime plot 5B; Nitrogen and Lime plot 1A; Biocide plot 1E). This is mirrored for the cumulative biomass (1999 to 2001) for all treatments except Nitrogen. Conversely the highest biomass levels are generally found within plots which are more centrally located on the site (eg Nitrogen and Lime plot 2E; Lime plot 2C; Biocide plot 2D and Control 1 plot 2B).

There is a strong positive correlation between surface soil pH and biomass (Fig 9) but no significant difference in biomass sampled between blocks (Genstat 5, ANOVA F=0.69,df=5,4,20,p= 0.61NS – see Appendix 1 for values).

ACKNOWLEDGEMENTS

I would like to thank Sarah Buckland for her help following my appointment as Officer in Charge at Sourhope and her assistance during the summer 2001 Point Analysis Survey. I am also grateful for the support of MLURI farm staff at Sourhope, Richard Scott, Mandy Lane, Peter Millard and fellow members of the Soil Biodiversity Programme.

Table 1 Data collection on the main Soil Biodiversity field experiment at Sourhope

- **Soil pH**

  9th March 2001 & 16th October 2001
  40ml of de-ionized water was mixed into *c*.25g soil (0-5cm deep) and allowed to stand for 20 minutes before measurement. One sample was taken from the centre of each plot.

- **Above-ground productivity**
  5th – 18th May (*) **4th – 8th Jun** **3rd – 18th Jul (*)**
  6th – 14th Aug **4th – 11th Sep**
  (*) includes periods where mower unavailable due to mechanical breakdown

  A Kubota riding grass mower was used at 3 weekly intervals during the summer to cut vegetation on the site to *c*.6cm. Prior to each mow, random $0.5m^2$ quadrats in each of sub-plots S, T, U & V were located on each plot and cut to *c*.6cm, using hand-held mechanical grass shears. The clippings were collected, oven-dried at 80^0C and subsequently weighed.

- **Botanical surveys**

  16th July to 3rd August
  The same $0.5m^2$ cell within each of S, T, U & V sub-plots of each plot was allocated for use in a full botanical survey. A Point Quadrat frame, containing a grid of 100 5cm x 5cm cells, was placed over the cell. Large "pins" were then dropped into 25 of these smaller cells and a record made of each occasion a species was touched by the pin down the vegetation profile.

  14th to 17th August
  Small-scale relative cover vegetation survey around minirhizotron tubes in Control 1, Biocide, and Nitrogen & Lime plots (on behalf of Project 2113 – Macaulay Institute).

  22nd to 24th August
  Relative cover vegetation survey within disturbance/nutrient addition matrix in sub-plot Y of Control 1 plots (on behalf of Project 2133 – Lancaster University).

- **Weather data**

  An Automatic Weather Station is located on the site. This was regularly downloaded and transmitted to the Soil Biodiversity Data Manager at CEH, Merlewood.

Table 2 Schedule of site activity 1998 to 2001

	1998	1999	2000	2001
Soil sampling	2	63	68	31
Measurement	1	13	33	12
Experimental set up/input	0	9	15	4
Other	0	5	12	9
Total	**3**	**90**	**128**	**56**

Table 3 Soil Biodiversity Site Automatic Weather Station – headline measures 1999 to 2001

	Total rainfall (mm)	Total radiation (MJ m^{-2})	Avge soil moisture content (m^3 m^{-3})	Avge air temp 2m (^{0}C)	Avge air temp 2cm (^{0}C)	Avge soil temp ^{0}C -2cm	Avge soil temp ^{0}C -5cm	Avge soil temp ^{0}C -10cm	Avge soil temp ^{0}C -20cm
1999	845	3439	0.30	8.17	8.33	8.65	8.64	8.65	8.57
2000	1209	3472	0.35	7.47	8.00	8.12	8.08	8.07	8.04
2001	839	3473	0.37	7.28	7.66	7.72	7.67	7.66	7.62

Table 4 Results of split plot ANOVA (Genstat 5) examining the effect of Treatment on shoot biomass harvested over the summer in (a) 1999, (b) 2000 and (c) 2001. Estimates of shoot biomass were made at each of the five mowing occasions conducted during each summer, when vegetation was collected from random 0.5m^2 cells in each of S, T, U & V sub-plots in each plot. Dried weights were summed, to give a total annual biomass, and then ln-transformed for the purpose of these analyses.

	Source of variation	*df*	SS	MS	*F*-ratio	*P*
a)	Block stratum	4	0.415	0.104	1.17	
	Block.Plot stratum					
	Treatment	5	1.798	0.360	4.07	
	0.010					
	Residual	20	1.766	0.088	2.24	
	Block.Plot.Subplot stratum	90	3.548	0.039		
	Total	119	7.526			
b)	Block stratum	4	0.206	0.052	1.81	
	Block.Plot stratum					
	Treatment	5	6.550	1.310	46.07	
	0.001					
	Residual	20	0.569	0.028	1.30	
	Block.Plot.Subplot stratum	90	1.973	0.022		
	Total	119	9.300			
c)	Block stratum	4	0.265	0.066	0.66	
	Block.Plot stratum					
	Treatment	5	5.838	1.168	11.62	
	0.001					
	Residual	20	2.009	0.100	4.13	
	Block.Plot.Subplot stratum	90	2.187	0.024		
	Total	119	10.300			

Table 5 Results of ANOVA examining the inter-year effects of treatment on shoot biomass (a) 1999 to 2000 and (b) 1999 to 2001

	Source of Variation	*df*	SS	MS	*F*-ratio	*P*
a)	Block stratum	4	0.368	0.092	1.11	
	Block.Plot stratum					
	Treatment	5	7.515	1.503	18.17	0.001
	Residual	20	1.654	0.083	2.40	
	Block.Plot.Subplot stratum	90	3.101	0.034	1.17	
	Block.Plot.Subplot "Units" stratum					
	Year	1	2.747	2.747	93.38	0.001
	Treatment.Year	5	0.832	0.166	5.66	0.001
	Residual	114	3.354	0.029		
	Total	239	19.571			
b)	Block stratum	4	0.564	0.141	1.00	
	Block.Plot stratum					
	Treatment	5	13.005	2.601	18.47	0.001
	Residual	20	2.817	0.141	3.89	
	Block.Plot.Subplot stratum	90	3.259	0.036	1.31	
	Block.Plot.Subplot "Units" stratum					
	Year	2	42.330	21.165	766.12	0.001
	Treatment.Year	10	1.180	0.118	4.27	0.001
	Residual	228	6.299	0.028		
	Total	359	69.453			

Table 6 Comparison of the percentage rank abundance of species in the point quadrat botanical surveys conducted in July 2000 and July 2001. Species are ranked based upon the total number of hits per treatment. The total rank abundance of each species across the entire site is also shown. Litter is excluded.

Control 1

	% of total hits 2000	% of total hits 2001	2001 cf 2000
Ac	33.39	23.48	(29.68)
Fo	15.99	17.68	10.61
Rs	9.57	16.67	74.13
Av	11.11	10.36	(6.76)
Ao	9.92	8.77	(11.55)
Ns	7.73	5.81	(24.86)
Pp	5.16	3.26	(36.84)
Tr	0.94	3.05	224.62
Dc	0.09	2.10	2133.06
Fr	2.35	1.48	(37.14)
Pe	0.31	1.30	316.84
Lm	0.78	1.04	32.99
Df	1.13	0.97	(13.85)
Liv		0.93	
Mc	0.19	0.70	272.18
Cx	0.03	0.58	1760.88
Gs	0.06	0.47	644.35
Ra	0.03	0.39	1140.59
Hm	0.84	0.31	(63.24)
Cp	0.03	0.27	768.41
Ll	0.13	0.16	24.06
Lp	0.06	0.08	24.06
Ls		0.08	
Pt	0.16	0.08	(50.38)

Nitrogen

	% of total hits 2000	% of total hits 2001	2001 cf 2000
Fo	20.24	27.61	36.38
Ac	29.93	21.77	(27.28)
Fr	10.00	10.22	2.20
Av	12.86	8.99	(30.11)
Rs	5.65	9.47	67.40
Pp	7.74	5.39	(30.34)
Ao	5.52	5.15	(6.81)
Ns	2.06	3.12	51.34
Gs	0.33	1.74	423.42
Df	2.11	1.35	(35.72)
Lm	1.02	1.25	22.64
Pe	0.27	0.84	215.02
Hm	0.78	0.58	(25.23)
Tr	0.38	0.53	41.12
Cx	0.07	0.39	481.58
Ls		0.39	
Mc	0.09	0.35	299.84
Pt	0.27	0.35	33.28
Cp	0.38	0.19	(48.68)
Ll	0.27	0.19	(27.30)
Ra	0.04	0.06	45.39
Vc		0.06	

Lime

	% of total hits 2000	% of total hits 2001	2001 cf 2000
Ac	34.63	28.32	(18.23)
Fo	12.56	17.99	43.25
Fr	7.19	10.90	51.57
Pp	10.18	10.19	0.08
Rs	8.21	9.07	10.49
Pt	0.93	5.91	536.72
Av	10.01	3.88	(61.17)
Ao	4.23	3.04	(28.15)
Ns	3.80	2.28	(40.05)
Tr	2.99	2.05	(31.45)
Dc	0.17	1.72	886.24
Hm	1.51	1.56	3.45
Lm	1.16	0.72	(38.14)
Rr		0.62	
Mc	0.20	0.47	130.55
Ll	0.23	0.39	68.11
Pe	0.17	0.35	101.73
Cp	0.29	0.16	(46.20)
Ra	0.44	0.16	(64.14)
Vc		0.16	
Cx	0.15	0.08	(46.20)
Df	0.96		(100.00)

N&L

	% of total hits 2000	% of total hits 2001	2001 cf 2000
Fr	14.55	26.31	80.91
Ac	35.78	20.40	(42.99)
Fo	11.08	14.63	31.98
Pp	15.69	13.82	(11.92)
Rs	1.90	6.05	217.36
Pt	4.37	3.82	(12.58)
Av	4.00	3.14	(21.48)
Hm	5.67	2.81	(50.45)
Dc	0.19	2.35	1108.50
Ao	2.71	2.08	(23.09)
Ns	1.34	1.88	40.06
Tr	0.87	1.44	66.66
Lm	0.89	0.50	(43.52)
Hl	0.52	0.30	(41.52)
Ls		0.15	
Pe	0.06	0.15	133.90
Pa		0.08	
Rr		0.08	
Cx	0.02		(100.00)
Cp	0.11		(100.00)
Df	0.11		(100.00)
Gs	0.04		(100.00)
Mc	0.02		(100.00)
Ra	0.06		(100.00)

Biocide

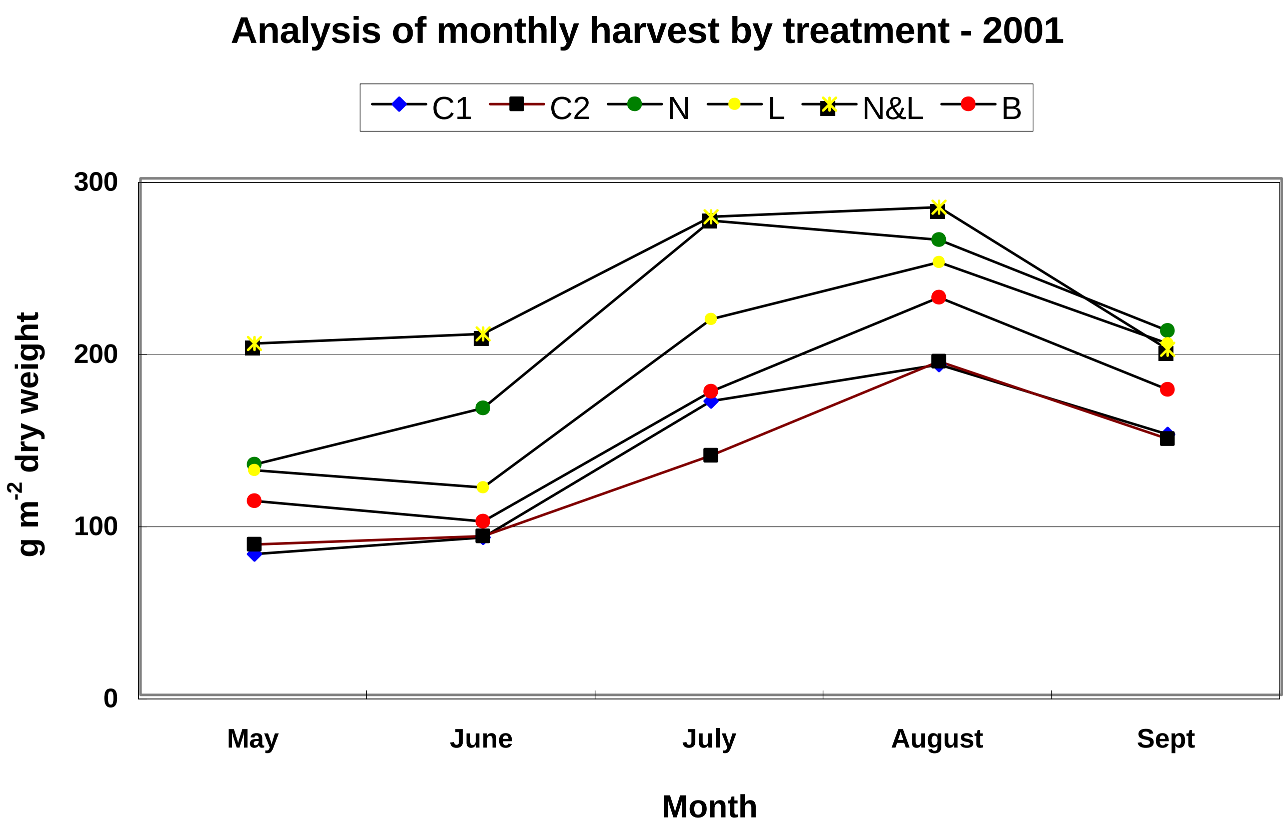
	% of total hits 2000	% of total hits 2001	2001 cf 2000
Fo	14.2	24.9	75.34
Ac	26.8	21.9	(18.30)
Rs	8.7	12.1	39.70
Av	19.0	9.5	(50.03)
Pp	6.2	5.8	(6.96)
Ns	6.0	5.0	(17.12)
Ao	5.9	4.2	(28.53)
Fr	5.4	3.5	(34.88)
Pe	1.0	2.4	131.41
Tr	2.3	2.3	(1.14)
Ls		2.1	
Gs	0.3	1.3	385.06
Lm	1.7	1.3	(20.94)
Hl		1.2	
Ra	0.2	0.5	191.04
Vm		0.5	
Cp	0.2	0.3	45.52
Df	1.3	0.3	(77.17)
Cip		0.2	
Pt	0.1	0.2	118.28
Ll	0.1	0.2	45.52
Cx	0.2	0.1	(41.79)
Lp	0.3	0.1	(73.54)
Mc	0.2	0.1	(58.42)
Hm	0.0		(0.02)

Total

	% of total hits 2000	% of total hits 2001	2001 vs 2000
Ac	32.03	23.08	(27.95)
Fo	14.85	20.87	40.52
Rs	6.48	10.64	64.25
Fr	8.41	10.45	24.26
Pp	9.29	7.59	(18.27)
Av	11.25	7.26	(35.51)
Ao	5.42	4.65	(14.21)
Ns	3.92	3.61	(7.85)
Pt	1.29	1.99	54.34
Tr	1.42	1.82	27.64
Dc	0.09	1.17	1190.12
Hm	1.90	1.03	(46.10)
Pe	0.36	1.01	177.78
Lm	1.11	0.98	(11.46)
Gs	0.15	0.75	396.70
Ls		0.56	
Df	1.11	0.55	(50.52)
Mc	0.13	0.32	149.64
Hl	0.12	0.31	153.99
Cx	0.10	0.24	139.48
Ra	0.14	0.22	55.51
Cp	0.21	0.18	(11.50)
Ll	0.15	0.18	25.12
Liv		0.18	
Rr		0.13	
Vm		0.10	
Cip		0.04	
Vc		0.04	
Lp	0.07	0.03	(55.34)
Pa		0.01	

Species codes: Ac, *Agrostis capillaris* ;Ao, *Anthoxanthum odoratum* ; Av, *Agrostis vinealis* ; Cp, *Carex panicea* ; Cx, *Carex* spp (incl *C. binervis* plus possibly *C. nigra* & *C. pilulifera*); Cip, *Cirsium palustre* ; Dc, *Deschampsia cespitosa* ; Df, *Deschampsia flexuosa* ; Fo, Festuca ovina; Fr, Festuca rubra; Gs, Galium saxatile; Hl, *Holcus lanatus* ; Hm, *Holcus mollis* ; Liv, Liverwort sp.; Ll, *Lathyrus linifolius* ; Lm, *Luzula multiflora* ;
Lp, *Luzula pilosa* ; Ls, *Luzula sylvatica* ; Mc, *Molinia caerulea* ; Ns, *Nardus stricta* ; Pe, *Potentilla erecta* ; Pa, *Poa annua* ; Pp, *Poa pratensis* ; Pt, *Poa trivialis* ;Rr, *Ranunculus repens* ; Ra, *Rumex acetosa* ;
Rs *Rhytidiadelphus squarrosus* (includes other occasional bryophytes such as *Brachythecium rutabulum, Pleurozium schreberii* & *Hypnum* spp); Tr, *Trifolium repens* ; Vm, *Vaccinium myrtillus* ; Vc, *Veronica chamaedrys*
Other species observed at the site but not recorded within the point quadrat survey include: *Cardamine pratense* , *Cerastium fontanum* , *Helictotrichon pubescens* , *Juncus effusus* ; *Taraxacum officinale* .

Fig 1 Analysis of treatment differences between monthly above-ground harvests (May-Sep 2001)



Throughout this report the following keys apply:

Treatment	Short alphabetical	Colour
Control 1	C1	Blue
Control 2	C2	Black
Nitrogen	N	Green
Lime	L	Yellow
Nitrogen and Lime	N&L	Green & Yellow
Biocide	B	Red

Fig 2 (a) Above-ground biomass, summed from harvests made at each of the five cuts each summer from 1999 to 2001, highlighting % increase in samples in 2001 compared to 2000. (b) Treatment biomass estimates expressed as a percentage of C1 estimates in each year. * refers to columns which are significantly different (P<0.05) within years from C1 by LSD test after split-plot ANOVA (Table 4)

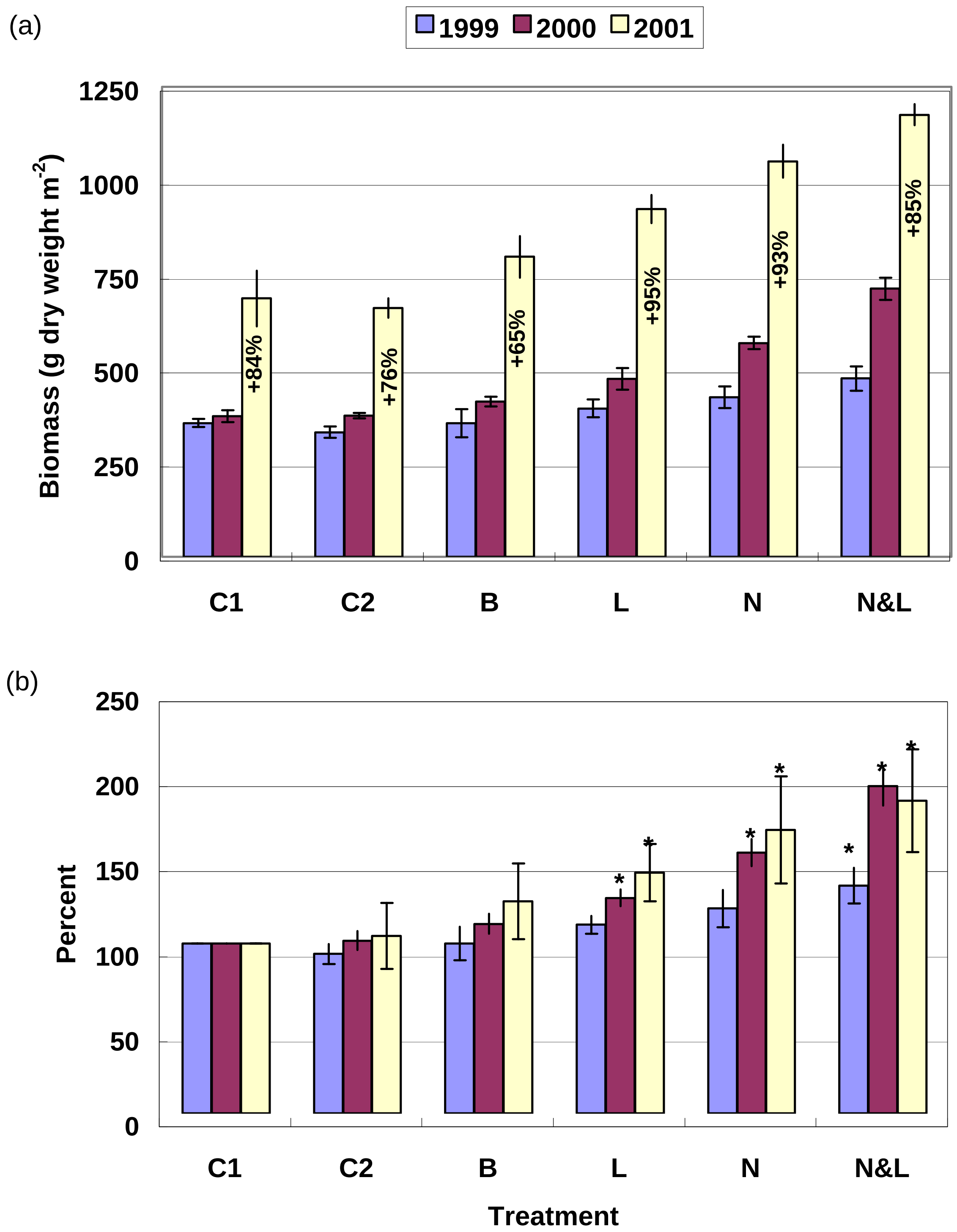


Fig 3 Changes in surface (to 5cm) soil pH (measured in distilled water) in October 2001 from the baseline measurements taken in August 1998. * refers to columns which are significantly different within years from C1 by LSD test after general ANOVA ($F=13.84$ $df=4,5,20$ $p<0.001$)

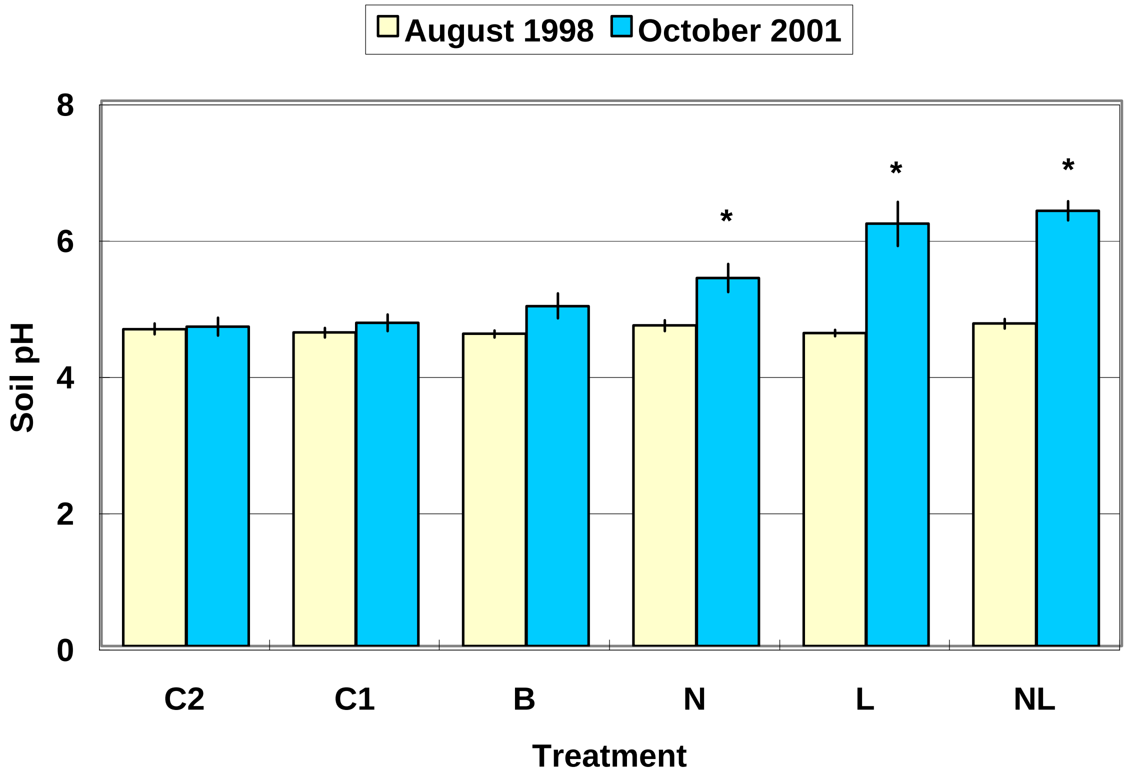


Fig 4 Rank abundance of the first ten species recorded in the Point Quadrat botanical survey in Jly/Aug 2001 (excl C2). Green columns highlight *Poa pratensis*, *Festuca rubra* and *Trifolium repens*, species commonly associated with improved pastures.

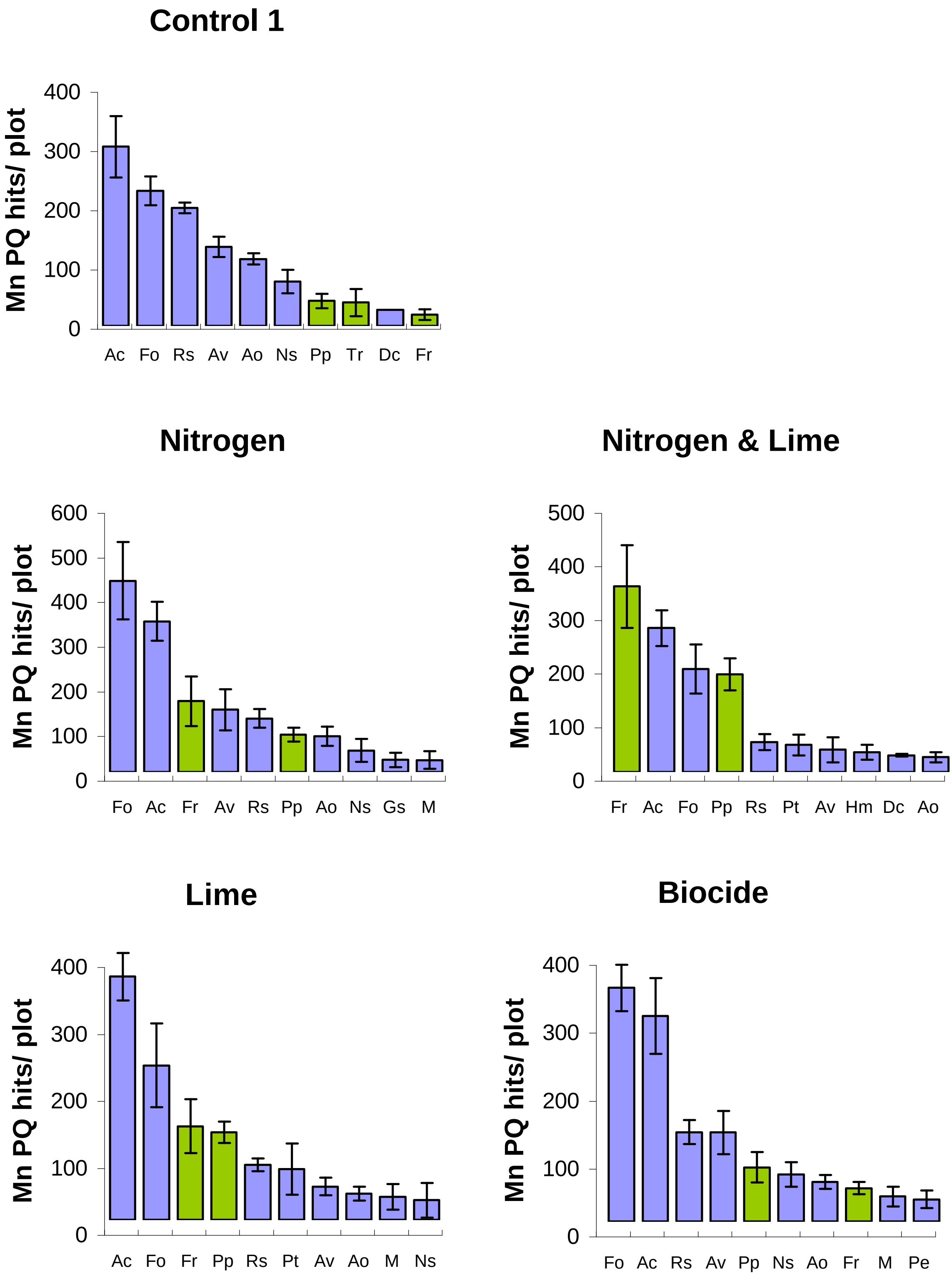
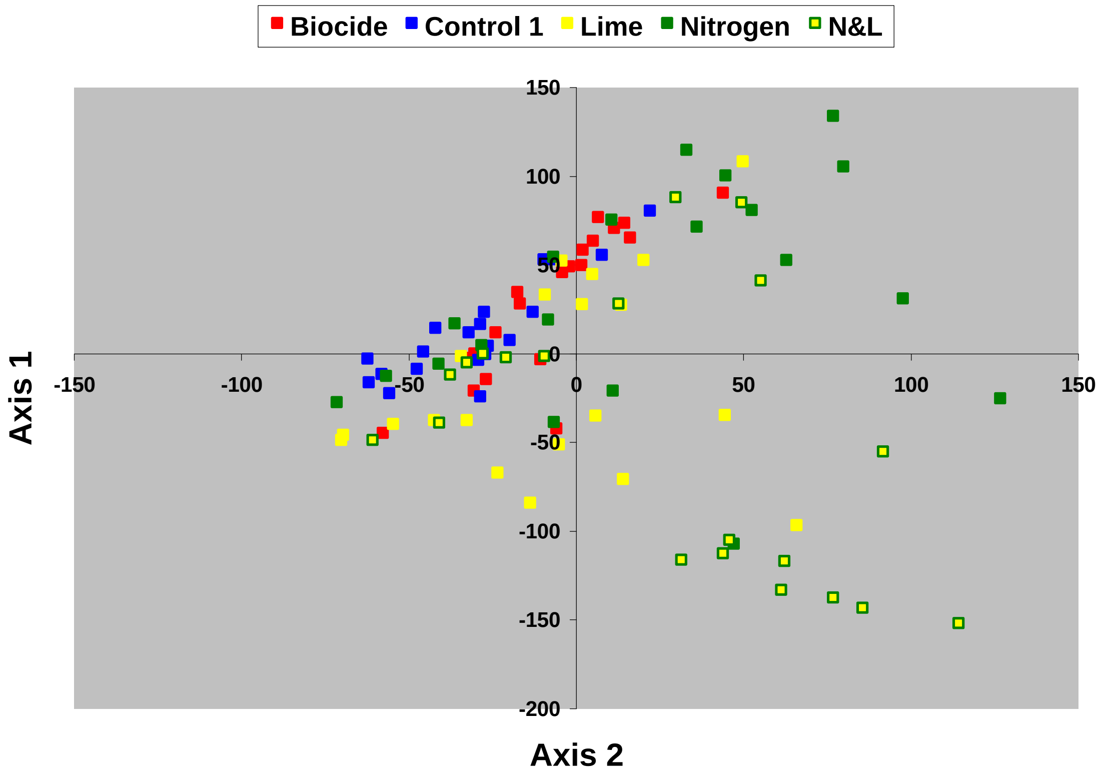


Fig 5 Principal Components Analysis on the point quadrat 2001 survey. Percentage variation in Axis 1 = 40.7% and Axis 2 = 20.8%. Genstat 5 used to generate PCA.
a) PCA scores for S,T,U & V quadrats in 25 plots (5 blocks, 5 treatments - excl Control 2)



b) A plot of PCA Latent Vector Loadings for major plant species

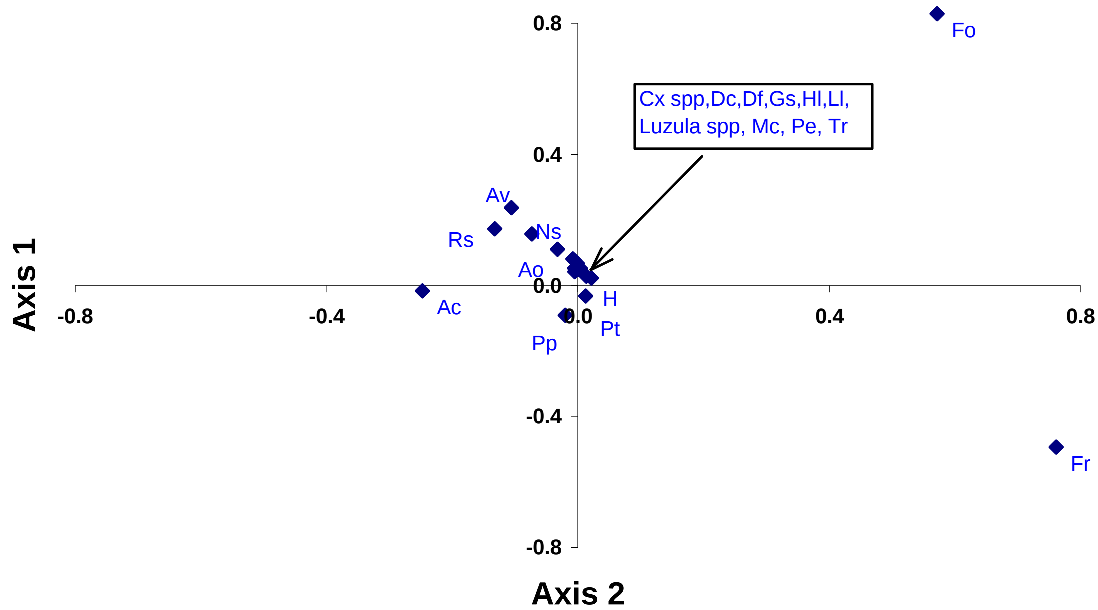


Fig 6 Point quadrat hits for individual plant species plotted against estimates of above ground biomass from 2001 summer cuts: Colour coding of points: Blue=Control 1, Green=Nitrogen, Yellow=Lime, Yellow & Green= Nitrogen & Lime, Red=Biocide.

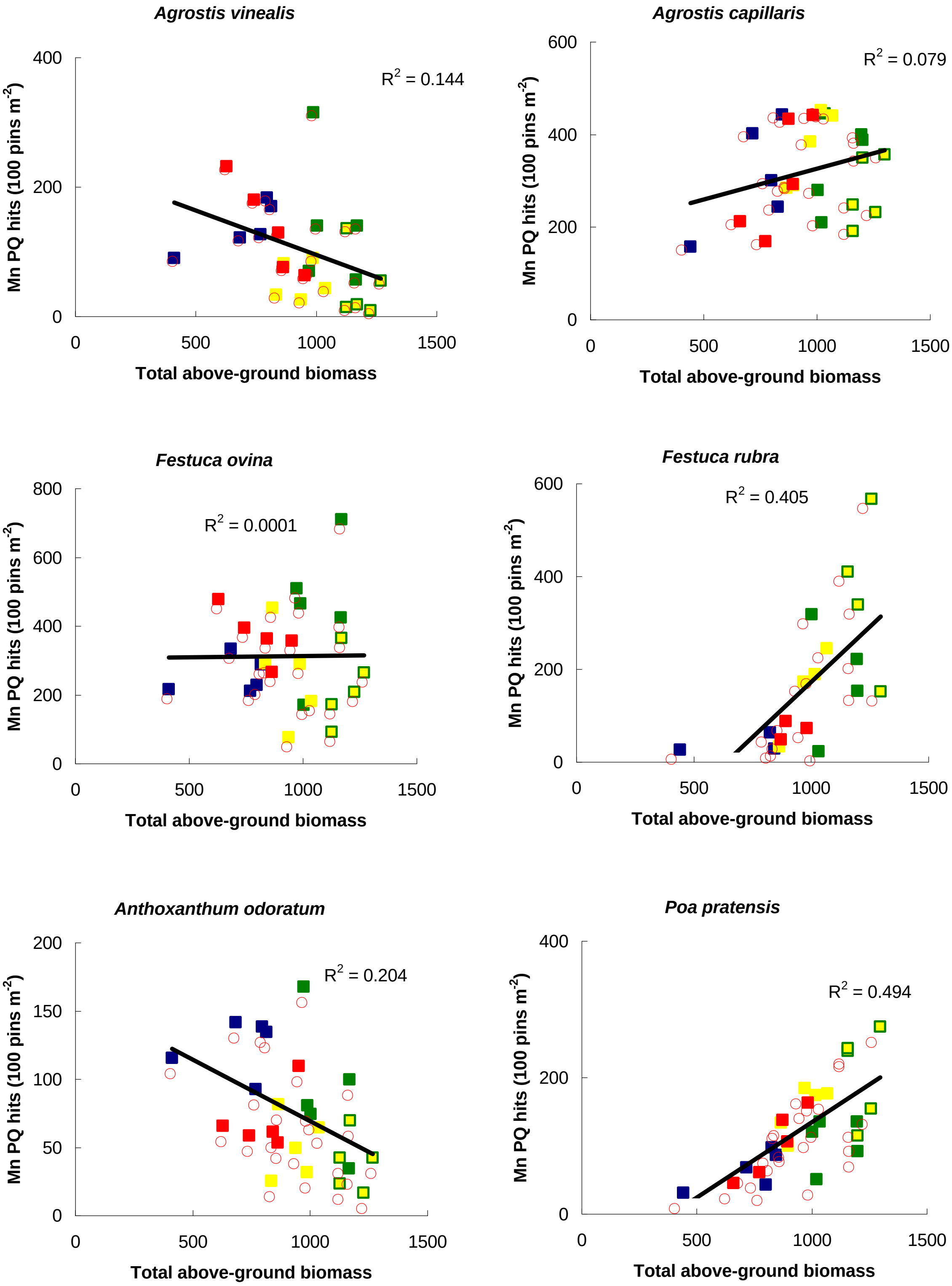


Fig 6 (cont) Point quadrat hits for individual plant species plotted against estimates of above-ground biomass from 2001 summer cuts: Colour coding of points: Blue=Control 1, Green=Nitrogen, Yellow=Lime, Yellow & Green= Nitrogen & Lime, Red=Biocide.

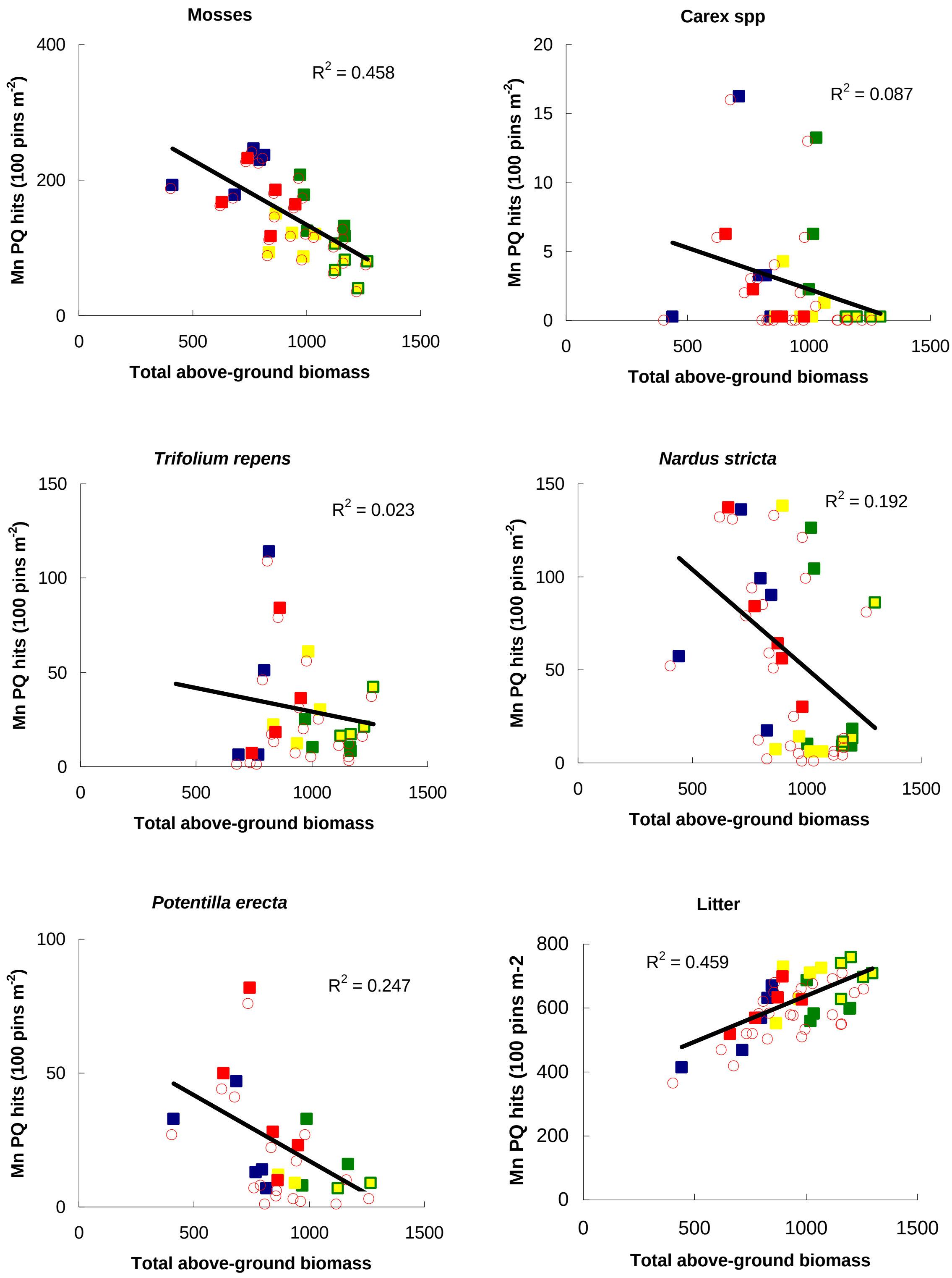


Fig 7 Soil pH of each plot (sampled in Mch & Oct 2001) plotted against columns at the site. Plot treatments are indicated by colour (Blue = Control 1, Black = Control 2, Green = Nitrogen, Yellow = Lime, Green andYellow = N&L, Red = Biocide).

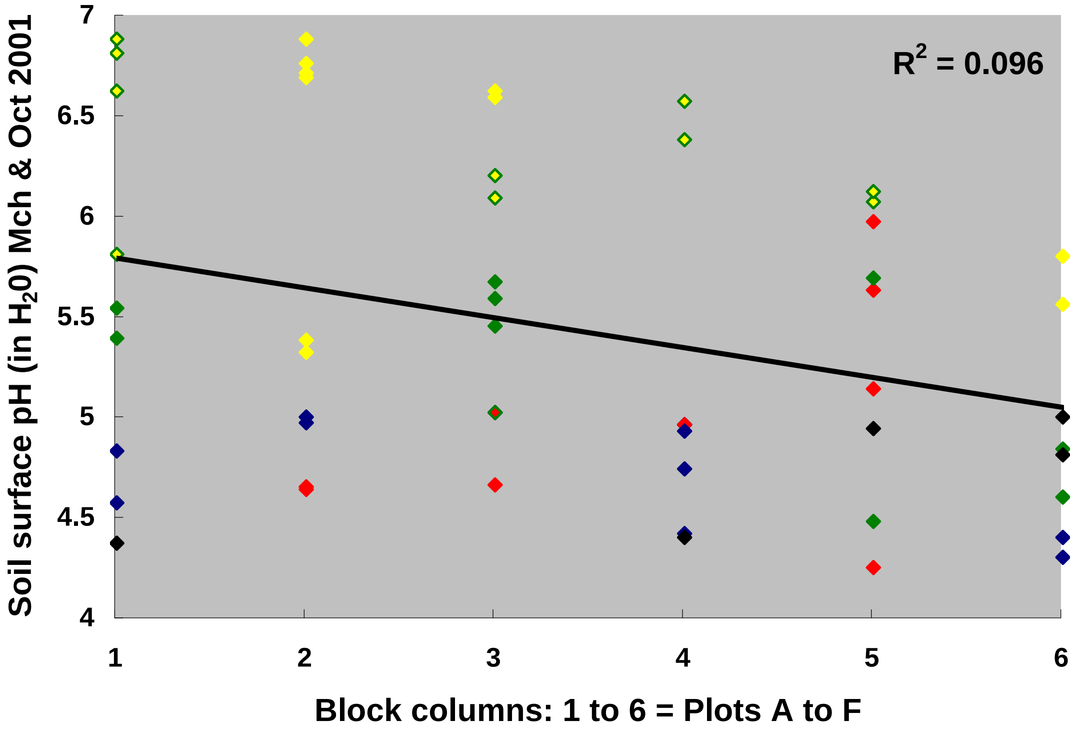
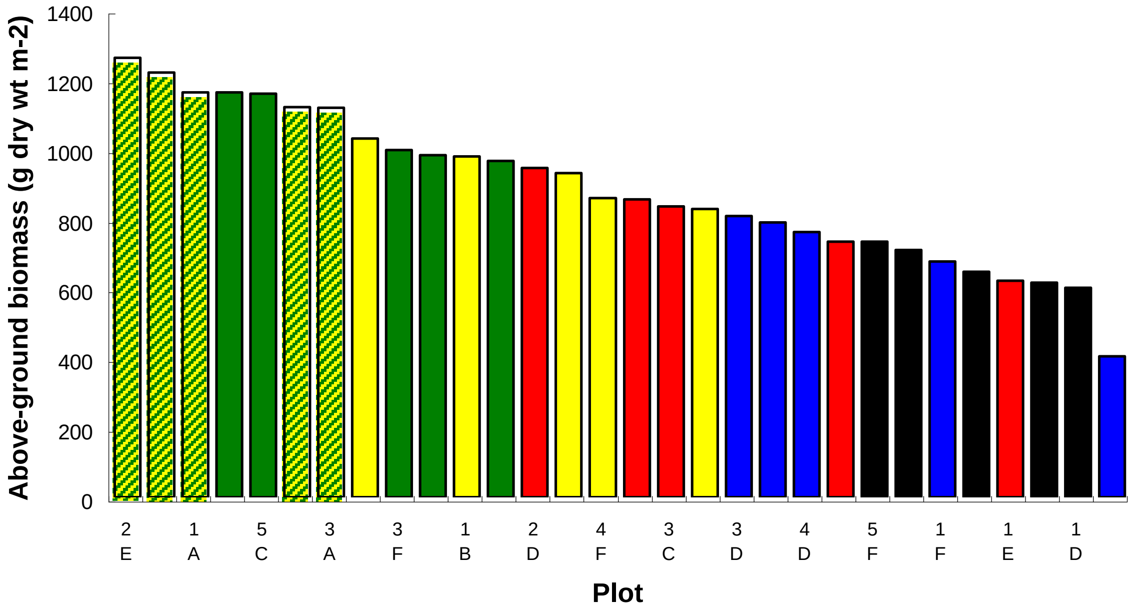


Fig 8 Rank in the above-ground biomass estimates for each plot obtained from the sum of the five summer samples collected at each mowing. Colour coding: Blue= Control 1, Black=Control 2, Green=Nitrogen, Yellow=Lime, Green & Yellow=N&L, Red=Biocide.
a) Biomass estimates for 2001



b) Cumulative biomass for 1999 to 2001

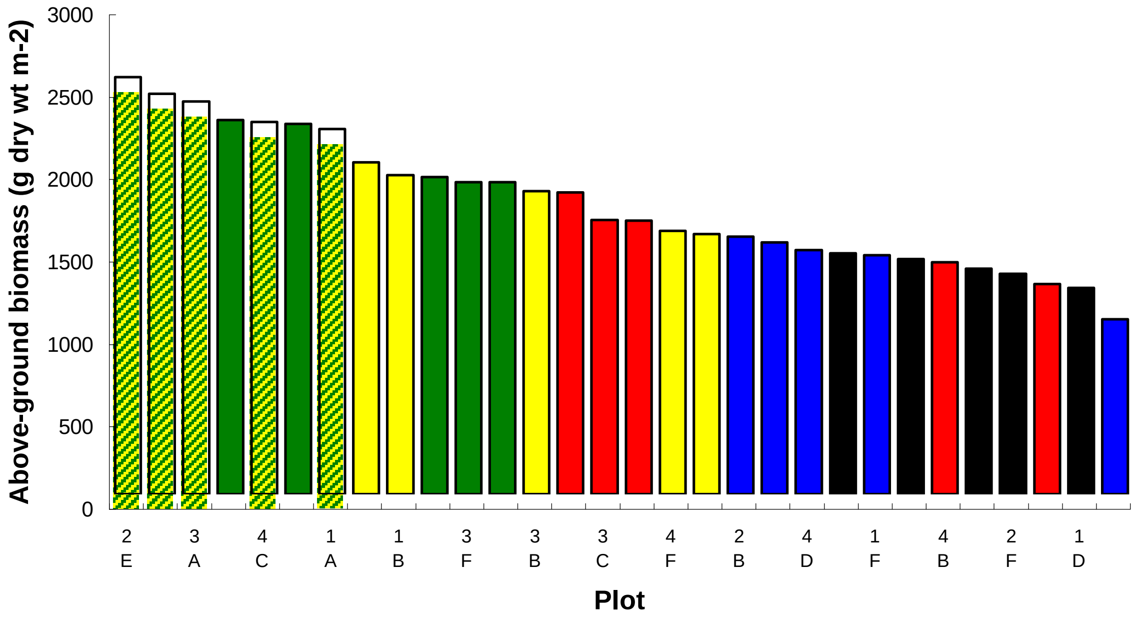
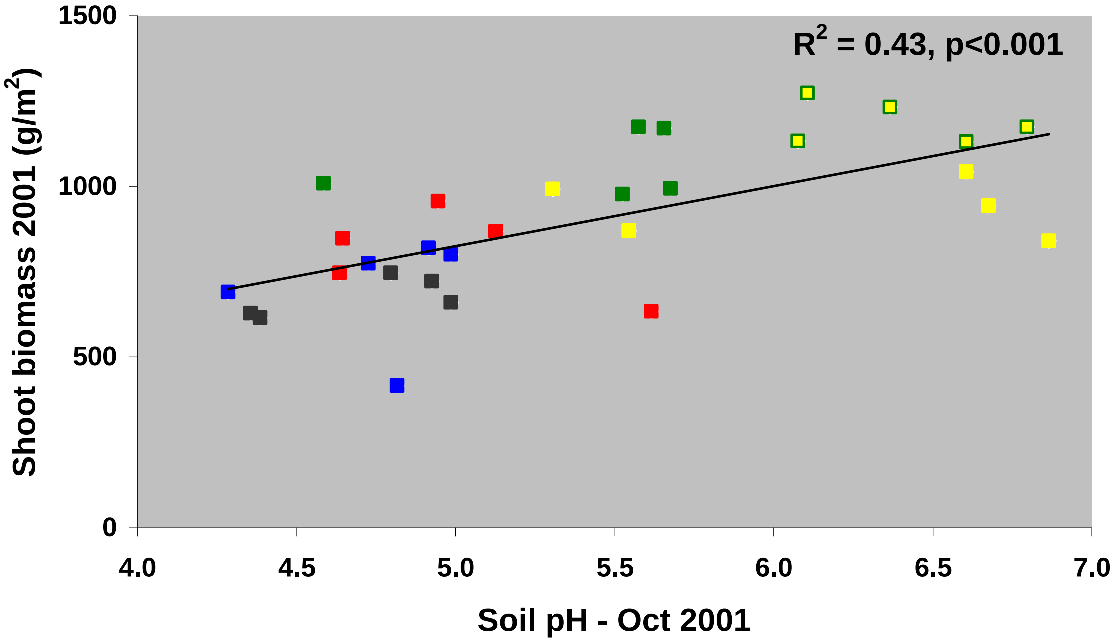


Fig 9 Above-ground biomass in summer 2001 plotted against soil pH measured in October 200.1Colour coding: Blue= Control 1, Black=Control 2, Green=Nitrogen, Yellow=Lime, Green & Yellow=N&L, Red=Biocide.



Appendix 1 Annualised above-ground biomass in each of the plots plus the mean of the five replicate blocks