Isotopic Evidence for Effects of Six Years of Fertilization on C and N Cycling in Moist Acidic Tundra

Erik Hobbie[1], Rodney Simpson[2], Jennie McLaren[3], Janet Chen[1], Laura Gough[4], John Moore[2], Gaius Shaver[5]

[1]University of New Hampshire, [2]Colorado State University, [3]University of Texas at El Paso, [4]University of Texas at Arlington, [5]Ecosystems Center, Marine Biological Laboratory

Introduction

· Mycorrhizal fungi influence plant N supply and N isotope patterns.

· Fertilization changes C allocation patterns in plants and often diminishes allocation to mycorrhizal fungi. Taxa of ectomycorrhizal and ericoid mycorrhizal fungi that have high C demands and strong enzymatic capabilities to degrade complex organic matter to obtain N and P appear particularly sensitive to nutrient fertilization.

· Based on prior unpublished results in moist acidic tundra (Figure 1), we predicted that $\delta^{15}N$ differences between nonmycorrhizal and arbuscular mycorrhizal (AM) plants and plants associating with ectomycorrhizal (ECM) and ericoid mycorrhizal (ERM) fungi would diminish with fertilization. This would reflect decreased C allocation to ECM/ERM fungi, decreased importance of recalcitrant organic matter as a nutrient source, and diminished transfer of ^{15}N-depleted N by ECM and ERM fungi.

· A long-term fertilization (N & P) experiment in moist acidic tundra began in 2006.

· A biomass harvest (pluck) in 2012 was used to study plant responses to fertilization.

· Here, we report patterns in stable C and N isotopes (expressed as $\delta^{13}C$ and $\delta^{15}N$) across the treatments and species for insights into how fertilization altered C and N dynamics.

Methods

· Fertilization began in 2006 with the yearly addition of 0, 2, 5, or 10 g N/m^2 and 0, 1, 2.5, and 5 g P/m^2.

· Pluck samples were classified by tissue type (above, below, blade, fine root, green, live, and new leaves), to species if possible and to probable mycorrhizal type (Table 2).

· After measurement at UNH, $\delta^{15}N$ and $\delta^{13}C$ patterns were analyzed using multiple regression with species and treatment as nominal variables and %C, %N, and isotopic values as continuous variables.

Results

· With fertilization, $\delta^{15}N$ decreased in above and blade categories of NON/AM plants, and in *Eriophorum* roots (Fig. 2).

· $\delta^{15}N$ increased with fertilization in ericoid and ectomycorrhizal plants (Fig. 3) and in the hemiparasite *Pedicularis* (Fig. 2).

· Fertilization did not change $\delta^{15}N$ or $\delta^{13}C$ of fine roots and there were no significant effects of different factors on green (mosses), and live tissues (Table 1).

· With greater depth, fine roots increased in $\delta^{15}N$ by 1.6‰ and in $\delta^{13}C$ by 0.9‰ (Fig. 4).

Conclusions

· As predicted, N fertilization decreased differences in $\delta^{15}N$ between ECM/ERM and AM/NON plants.

· Increased $\delta^{15}N$ with fertilization in ectomycorrhizal/ericoid mycorrhizal plants suggests those fungi are no longer transferring ^{15}N-depleted N to host plants, and, probably , retaining less ^{15}N-enriched N as their biomass declines.

· Declines in $\delta^{15}N$ with fertilization for graminoids suggest parallel declines in the $\delta^{15}N$ of available N.

Fertilization has greatly disrupted N dynamics in mycorrhizal plants.

· $\delta^{15}N$ patterns in *Pedicularis* suggest that *Betula* and *Vaccinium vitis-idaea* are most likely hosts.

· Increase in root $\delta^{13}C$ with depth could reflect loss of ^{13}C-depleted C as lignin or CO_2 during transport or assimilation of ^{13}C-enriched organic N.

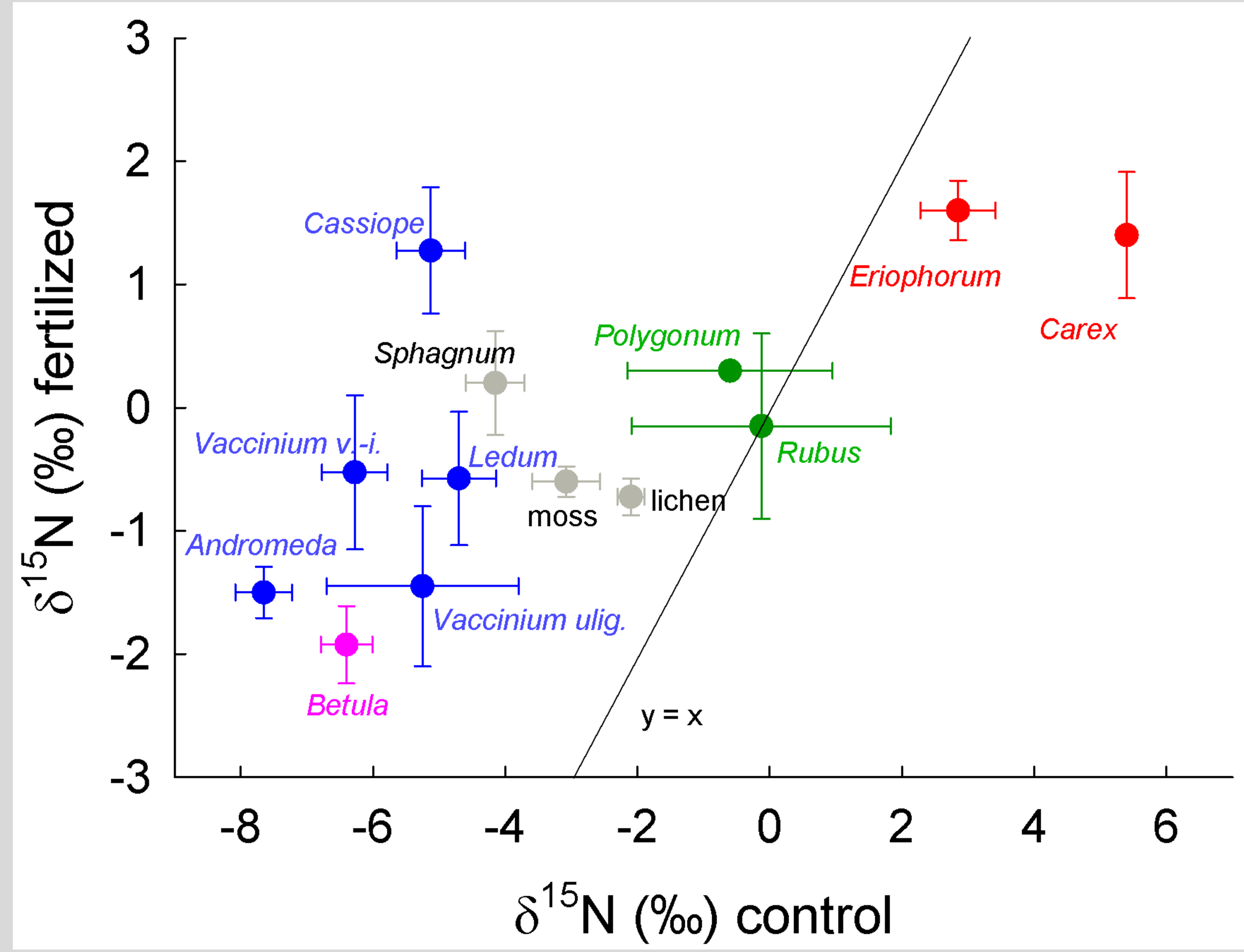

Figure 1. $\delta^{15}N$ values for plant foliage from moist acidic tundra. Data file 2000lgshttcn archived on ARC LTER website. Collected after 5 yr fertilization (1996-2000) at 10 g N & 5 g P/m^2/yr by L. Gough, S. Hobbie, and G. Shaver. Mycorrhizal type: blue, ERM; pink, ECM; green, AM; red, nonmycorrhizal.

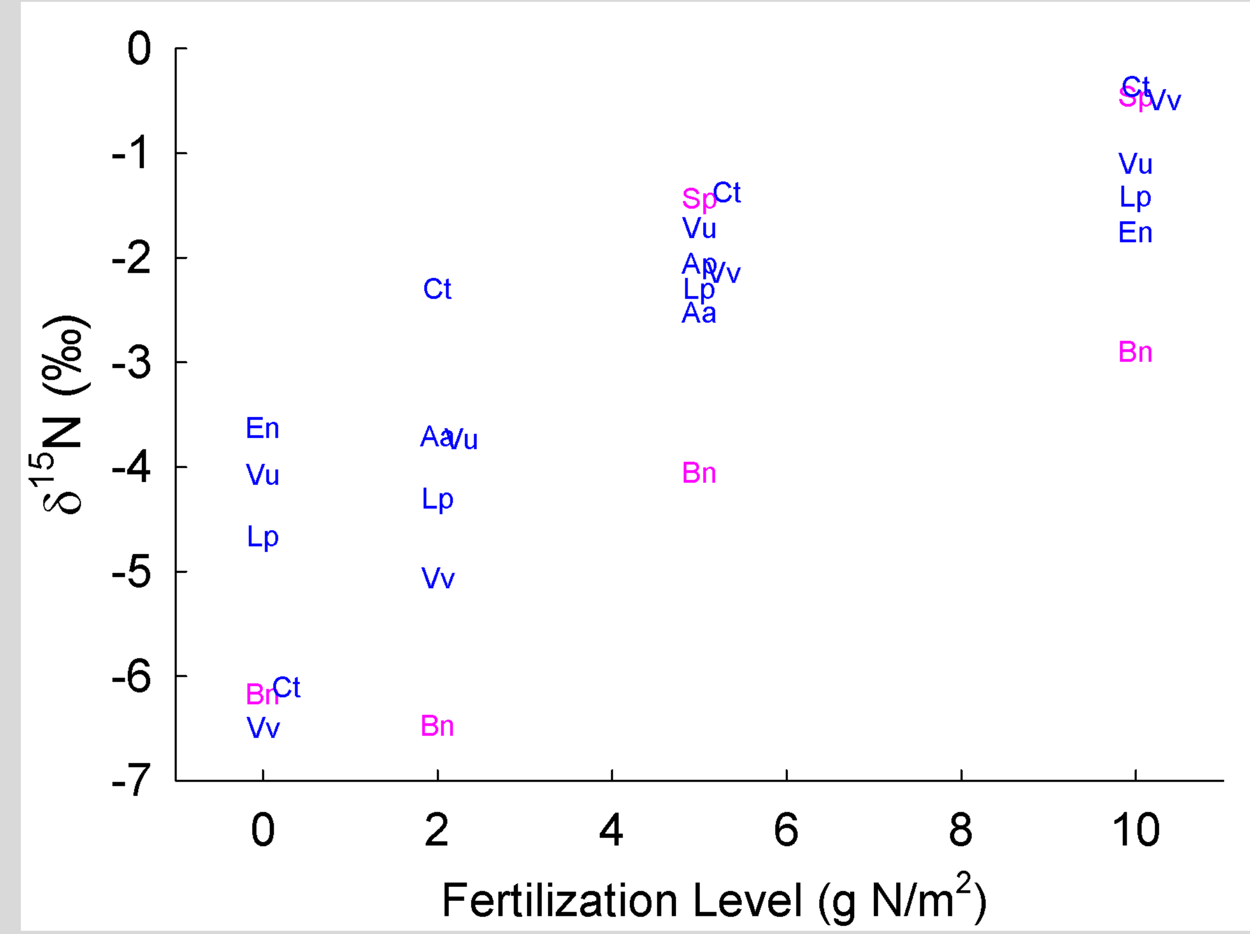

Figure 3. $\delta^{15}N$ for ERM and ECM plant new leaves (Ap, Aa, En, Lp, Vu, Vv, Bn, Sp) and stems (Ct only) increases with fertilization level. Error bars omitted for clarity. Collected after 6 yr fertilization.

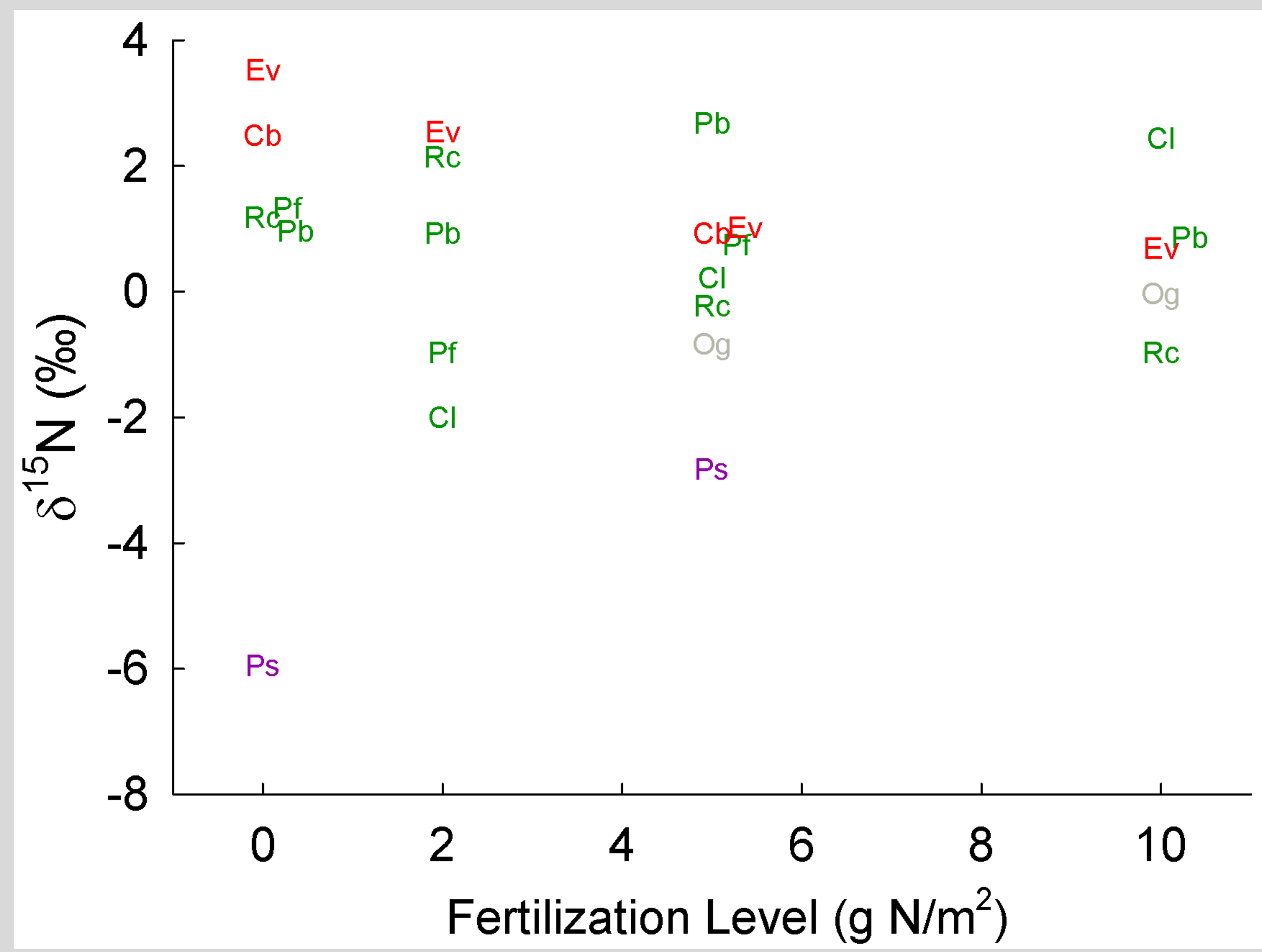

Figure 2. $\delta^{15}N$ for NON/AM graminoid blade (Cb, Ev, Og, Cl) and additional above ground tissue (Pf, Pb, Rc, Ps) often decline with fertilization while hemiparasitic plants increase. Error bars omitted for clarity. Collected after 6 yr fertilization.

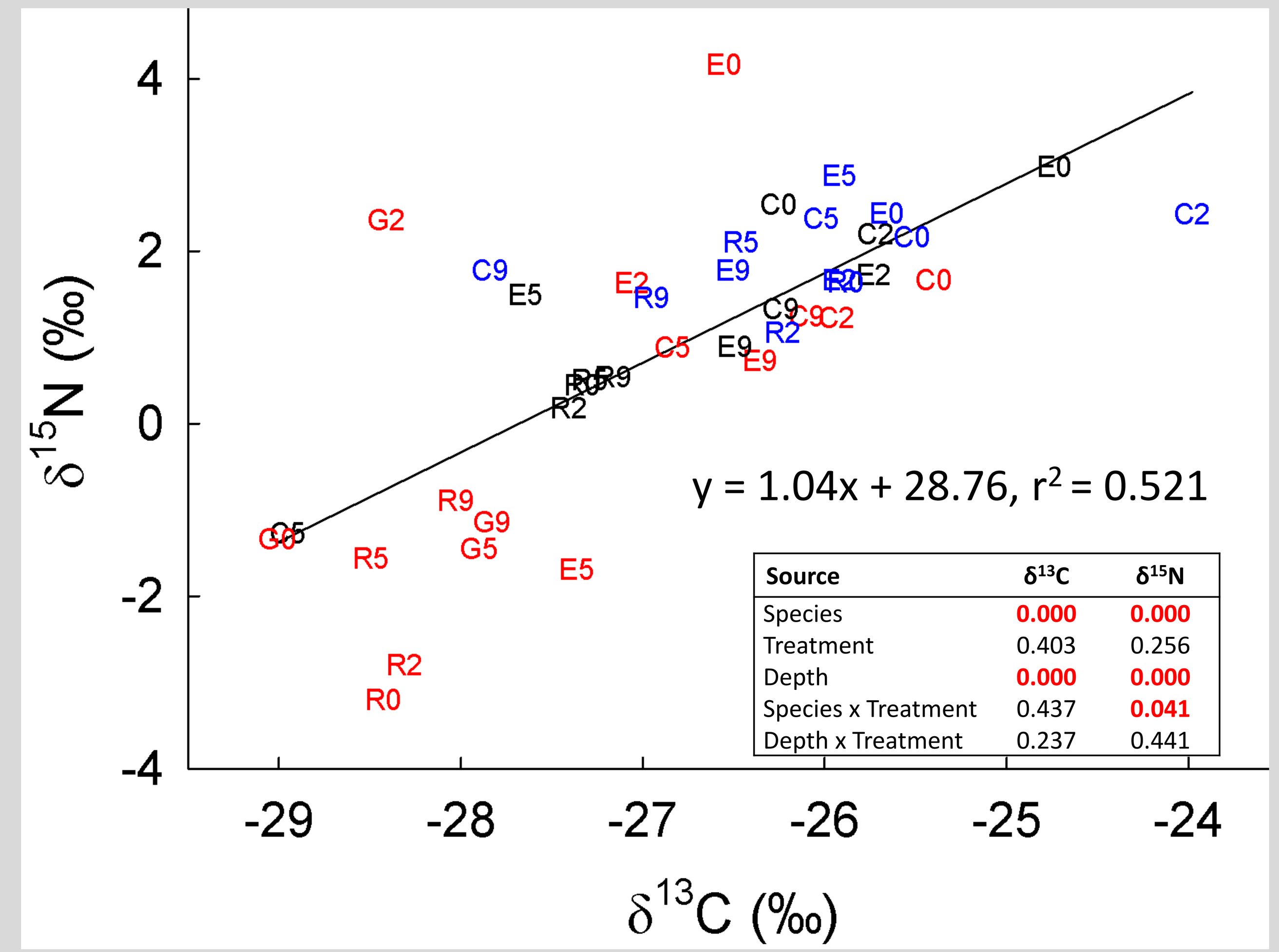

Figure 4. $\delta^{15}N$ and $\delta^{13}C$ for fine roots are correlated and increase with depth. *Soil depth*: red, organic; black, transition; blue, mineral. *Species*: C, *Carex*; E, *Eriophorum*, G, graminoid, R, other roots. *Fertilization treatment*: 0, control; 2, F2, 5, F5; 9, F10. Error bars omitted. Collected after 6 yr fertilization.

Table 1. Significance of different factors on $\delta^{15}N$ in tissues from multiple regressions. No significant effects on green (*Sphagnum*, mosses) and live tissues.

Tissue Parameter	New leaves $\delta^{15}N$	Blade $\delta^{15}N$	Fine roots $\delta^{15}N$	Above ground $\delta^{15}N$	Below ground $\delta^{15}N$
Species	**0.000**	0.083	**0.029**	**0.001**	**0.009**
Treatment	**0.018**	**0.008**	0.952	**0.025**	0.212
%C	0.862	**0.012**	**0.019**	**0.006**	0.517
%N	0.073	0.261	0.531	**0.015**	0.313
$\delta^{15}N$ /$\delta^{13}C$	0.815	0.438	**0.000**	**0.021**	0.901

Table 2. Plants classified by probable mycorrhizal types.

Ericoid mycorrhizal: *Andromeda polifolia* (Ap), *Arctostaphylos alpina* (Aa), *Cassiope tetragona* (Ct), *Empetrum nigrum* (En), *Ledum palustre* (Lp), *Vaccinium uligonosum* (Vu), *V. vitis-idaea* (Vv)

Ectomycorrhizal: *Betula nana* (Bn), *Salix pulchra* (Sp)

Arbuscular mycorrhizal: *Calamagrostis lapponica* (Cl), *Petasites frigida* (Pf), *Polygonum bistorta* (Pb), *Rubus chamaemorus* (Rc)

Nonmycorrhizal: *Carex bigelowii* (Cb), *Eriophorum vaginatum* (Ev)

Hemiparasitic: *Pedicularis sp.* (Ps)

Other Graminoids: (OG)

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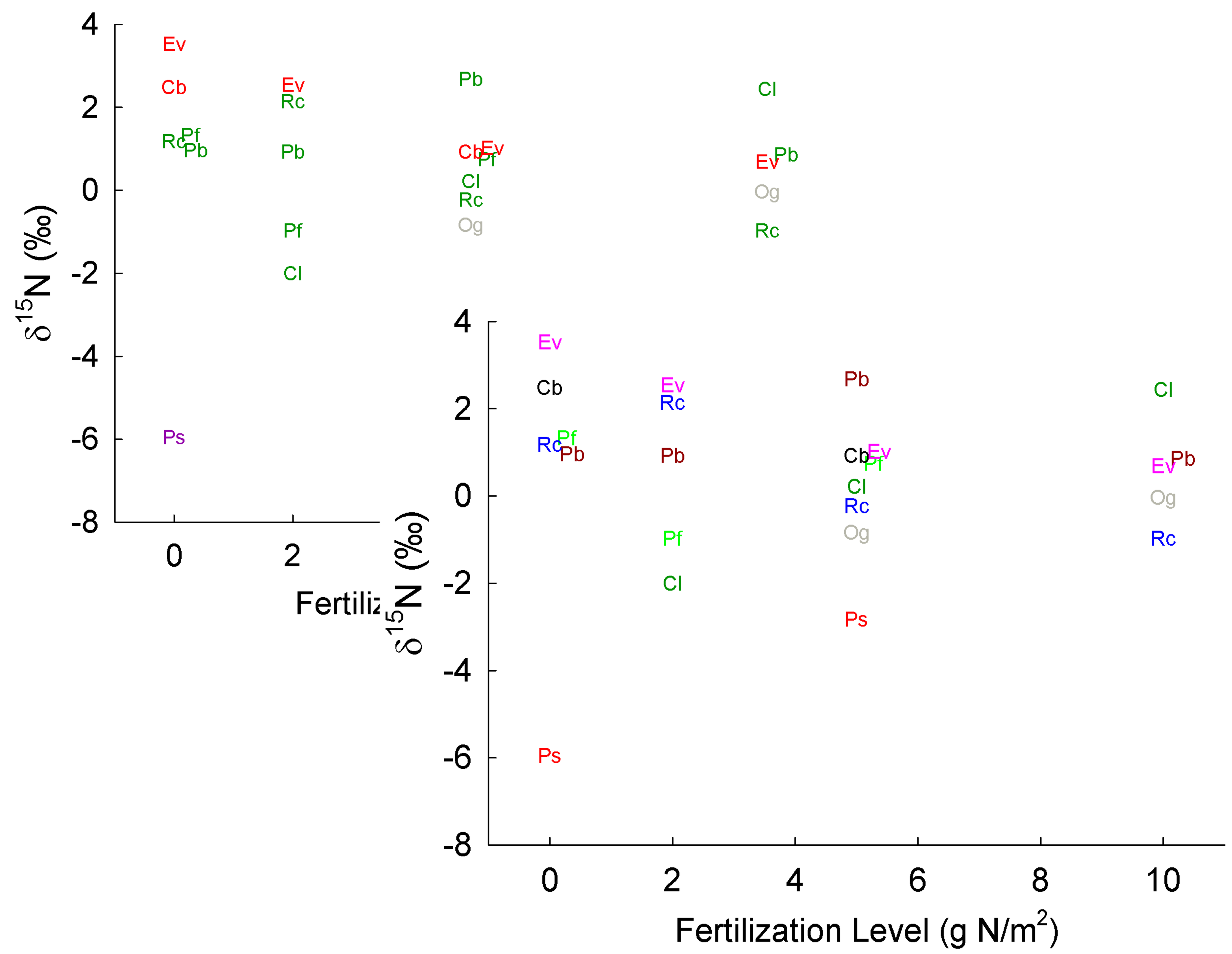
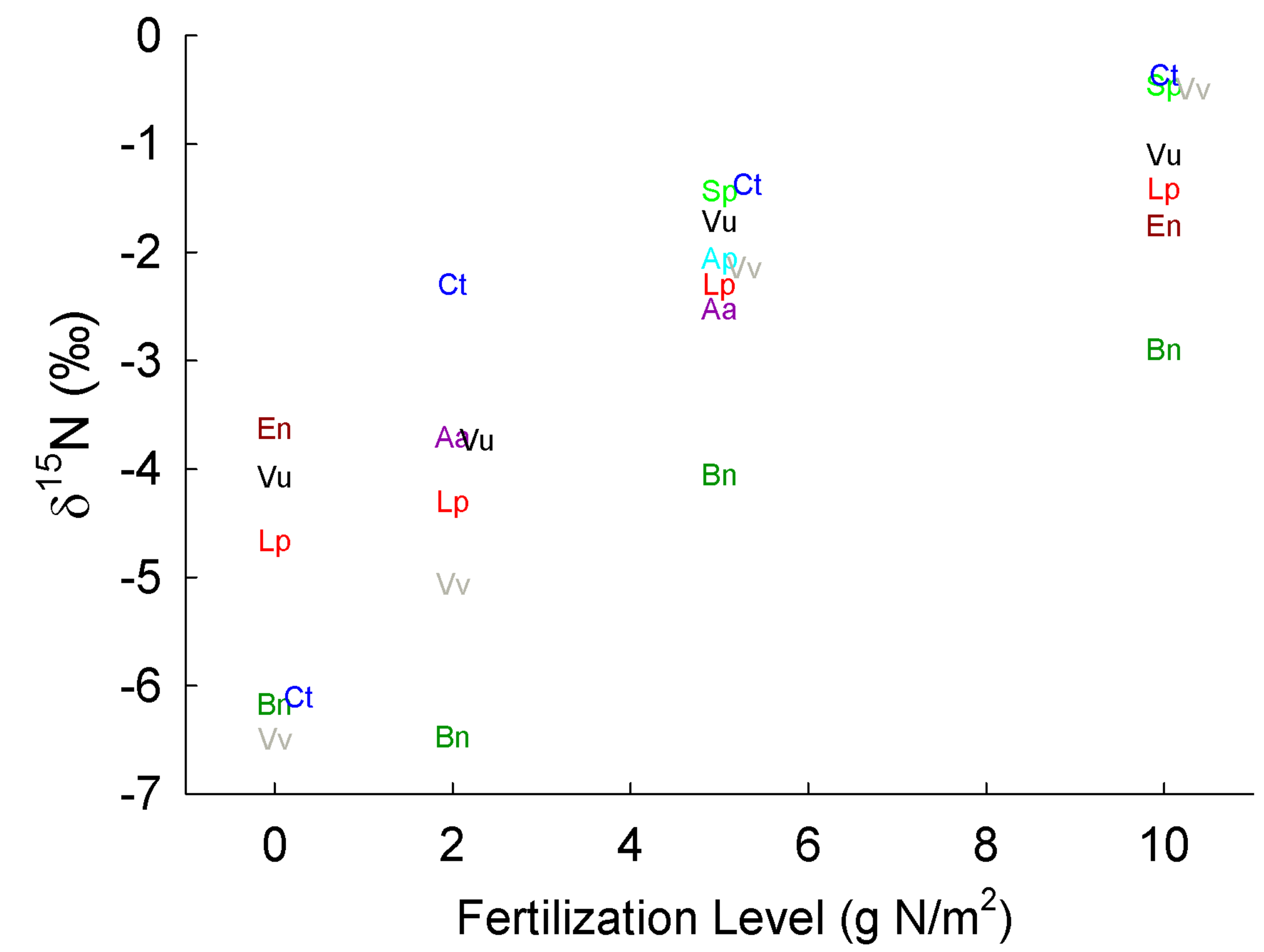

δ15N (‰)
Fertilization Level (g N/m2)
Ev
Cb
Rc
Pf
Pb
Cl
Og
Ps


δ15N (‰)
Fertilization Level (g N/m2)
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