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CAN PEATLAND PLANTS TAKE UP ORGANIC NITROGEN?

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SUMMARY

To test whether peatland plants can take up organic nitrogen, we applied dual-labelled (^{13}C and ^{15}N) glycine to the surface layer of the peat at two sites and sampled above and below ground plant tissues for C and N content and δ^{13}C and δ^{15}N. One site was a bog in Canada and the other was a restored bog in New Zealand. Nearly all plant species showed significant evidence of ^{15}N uptake in foliar tissues, but without any significant uptake of ^{13}C. Greater enrichment of ^{15}N occurred in the root tissues at both sites, with some evidence of ^{13}C enrichment.

KEY WORDS: nitrogen, bog, shrubs, mosses, sedges

INTRODUCTION

Dissolved nitrogen (N) in peat porewater is usually dominated by organic over inorganic ammonium (NH_4) and nitrate (NO_3) forms. Although uptake of organic N has been shown in other ecosystems (e.g. Chapin et al. 1993; Jones et al. 2005; Kielland et al. 2006), no studies have been published where organic N uptake was examined across multiple species in bogs. To test whether peatland plants can take up organic N, we applied dual-labelled (^{13}C and ^{15}N) glycine to the surface layer of the peat at two sites and sampled above and below ground plant tissues for C and N content and δ^{13}C and δ^{15}N.

MATERIALS AND METHODS

The Mer Bleue bog is located in eastern Ontario, Canada and comprises a mixture of hummocks and lawns with shrubs, sedges and mosses. Sixteen 20 x 50 cm experimental plots were established, half were on drier hummocks and half were located on wetter lawns. The plots contained mixtures of six dominant species: shrubs - *Chamaedaphne calyculata*, *Ledum groenlandicum* and *Vaccinium myrtilloides*; a sedge - *Eriophorum vaginatum*; and the mosses - *Sphagnum capillifolium* and *Sphagnum magellanicum*.

The Torehape peatland is located in the North Island, New Zealand and was dominated by restiad plants. It has been used for horticultural peat moss harvesting and an abandoned section is undergoing vegetation re-establishment. Eight small individuals of two restiad species, *Empodisma minus* and *Sporadanthus ferrugineus,* and the sedge *Baumea rubiginosa* were identified, separate from the overall vegetation.

At Mer Bleue, the effect of glycine addition was assessed by comparing species in the treated and control plots 72 hr after glycine addition. At Torehape, individual plants of each species were separated into controls or treated (4 each) and above-ground samples were collected just before glycine addition and after 48 hr. Roots were collected at both sites by digging up the peat and separating the roots from the peat by hand washing.

At both sites, either distilled water or a solution of dual-labelled (^{13}C and ^{15}N) glycine was added to the top 10 cm of the peat/vegetation layer. At Mer Bleue, injection occurred at 8 points in each plot; at Torehape, injection was at 5 points around each plant, enclosed in a 10 cm diameter tube.

Plant tissues were oven dried at 60ºC; mosses and roots were washed in 0.5 mM $CaCl_2$ to remove any residual sorbed glycine, then oven-dried. Samples were ground and analyzed for C and N concentration and δ^{13}C and δ^{15}N.

Peat porewater was extracted at both sites and analyzed for dissolved organic carbon (DOC), NH_4 and NO_3 and total dissolved nitrogen (TDN) and the Mer Bleue samples were also analyzed for amino acids.

RESULTS

Organic nitrogen dominated TDN in the peat porewater, with an average of 7% at Mer Bleue and 50% at Torehape of the TDN present as NH_4 and NO_3. In the Mer Bleue peat porewater, glycine was the most abundant amino acid (15 to 25% of total amino acid C), with 1.4 to 1.9% of the DOC present as amino acids.

At Mer Bleue, all species showed a significant increase in δ^{15}N in the foliar and root (separated into shrub and *E. vaginatum*) tissues (Table 1). However, there was no significant change in δ^{13}C in either foliar or root samples.

At the Torehape peatland, *E. minus* and *S. ferrugineus* showed a significant increase in δ^{15}N in foliar tissues, but *B. rubiginosa* did not and none of the species showed an increase in δ^{13}C (Table 2). All three species showed a significant increase in δ^{15}N, and to a lesser extent δ^{13}C, in the roots, when the glycine-treated individuals were compared with those treated only with distilled water.

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Table 1. Mean C and N concentration (%) and $\delta^{13}C$ and $\delta^{15}N$ (‰) of plant species at Mer Bleue, under control and glycine-treated conditions (standard error of mean in parentheses). *, ** and *** represent 0.05, 0.01 and 0.001 levels of significant difference between controls and glycine-treated samples for $\delta^{13}C$ and $\delta^{15}N$. n = 6 to 8.

Species	Control		Glycine		Control		Glycine	
	C	$\delta^{13}C$	C	$\delta^{13}C$	N	$\delta^{15}N$	N	$\delta^{15}N$
Above-ground:								
C. calyculata	52.3 (0.4)	-29.57 (0.14)	52.8 (0.4)	-29.25 (0.31)	1.24 (0.03)	-4.15 (0.91)	1.24 (0.05)	2.07 (1.29)**
L. groenlandicum	53.9 (0.3)	-28.86 (0.27)	53.4 (0.3)	-28.97 (0.22)	1.52 (0.06)	-6.88 (0.32)	1.46 (0.06	10.66 (5.99)*
V. myrtilloides	48.4 (0.3)	-30.94 (0.51)	48.4 (0.3)	-31.28 (0.23)	1.18 (0.06)	-4.99 (0.42)	1.26 (0.06)	29.10 (22.42)**
E. vaginatum	46.3 (0.4)	-27.45 (0.14)	46.7 (0.5)	-27.52 (0.32)	1.69 (0.06)	1.34 (0.32)	1.74 (0.04)	3.26 (0.50)**
S. capillifolium	42.6 (0.2)	-30.53 (0.37)	42.3 (0.1)	-30.53 (0.37)	0.73 (0.03)	-2.72 (0.17)	0.71 (0.03)	39.78 (16.57)*
S. magellanicum	45.3 (0.1)	-29.61 (0.37)	42.7 (0.2)	-29.00 (0.80)	0.69 (0.03)	-2.42 (0.18)	0.71 (0.03)	140.60 (83.37)**
Roots:								
Shrubs	49.2 (0.2)	-28.15 (0.13)	49.0 (0.3)	-27.84 (0.09)	0.73 (0.05)	-3.72 (0.48)	0.83 (0.05)	149.52 (25.35)***
E. vaginatum	46.5 (0.3)	-27.70 (0.52)	46.6 (0.4)	-25.52 (1.36)	0.65 (0.11)	2.03 (0.35)	0.42 (0.04)	40.50 (15.67)**

Table 2. As above, for plant species at Torehape. n = 4.

Species	Control (0 hr)		Glycine (after 48 hr)		Control (0 hr)		Glycine (after 48 hr)	
	C	$\delta^{13}C$	C	$\delta^{13}C$	N	$\delta^{15}N$	N	$\delta^{15}N$
Above-ground:								
B. rubiginosa	42.9 (0.3)	-28.95 (0.35)	53.6 (0.2)	-28.82 (0.47)	1.31 (0.03)	5.30 (0.28)	1.28 (0.05)	4.91 (0.58)
E. minus	45.6 (0.2)	-28.57 (0.51)	45.4 (0.7)	-28.79 (0.32)	1.33 (0.11)	6.40 (2.25)	1.30 (0.07)	15.33 (4.75)*
S. ferrugineus	45.0 (0.2)	-27.69 (0.46)	45.9 (0.4)	-27.81 (0.35)	0.92 (0.05)	10.67 (1.32)	0.87 (0.05)	23.19 (5.11)*
Roots:	Control		Glycine		Control		Glycine	
B. rubiginosa	47.6 (0.2)	-27.39 (0.29)	47.2 (0.3)	-25.82 (0.51)*	0.64 (0.07)	10.18 (0.75)	0.73 (0.08)	485 (105)*
E. minus	46.9 (0.0)	-26.90 (0.57)	46.3 (0.2)	-26.72 (0.54)	1.52 (0.11)	5.57 (1.27)	1.68 (0.11)	207 (51)*
S. ferrugineus	46.4 (0.2)	-27.62 (0.73)	47.0 (0.4)	-27.21 (0.27)	0.81 (0.03)	13.91 (2.33)	0.81 (0.09)	279 (27)**

DISCUSSION AND CONCLUSION

Schimel and Bennett (2004) proposed alternative mechanisms whereby soil N could be accessed by plants, based on the availability of inorganic forms of N, and that where inorganic N was low, organic forms could be taken up by plants.

Our results show that in these inorganic N-poor peatland systems, plants can access glycine, as organic N. There is a variation among species and under our experimental conditions, roots showed greater uptake of ^{15}N than the foliar tissues. Ensuring that roots have access to the added glycine is an issue. At the restored Torehape bog, porewaters contained more N (as

NH_4^+), than at Mer Bleue and this may have affected the organic N uptake patterns. The absence of significant ^{13}C uptake, along with ^{15}N, in the foliar and root tissues suggests that a cleavage between C and N in the glycine occurs in the soil or in the plant roots and that the ^{15}N may have been accessed in the inorganic forms. Alternatively, ^{13}C has been lost from the plant through respiration, leaving the residual ^{15}N.

Thus, the answer is, yes - these peatland plants can take up organic N, but it is variable among species and above- and below-ground. Our results suggest that microbial or mycorrhizal transformations occur in the rhizosphere which exclude the uptake of glycine-derived C.

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