Common mycorrhizal networks of European Beech trees drive belowground allocation and distribution of plant-derived C in soil

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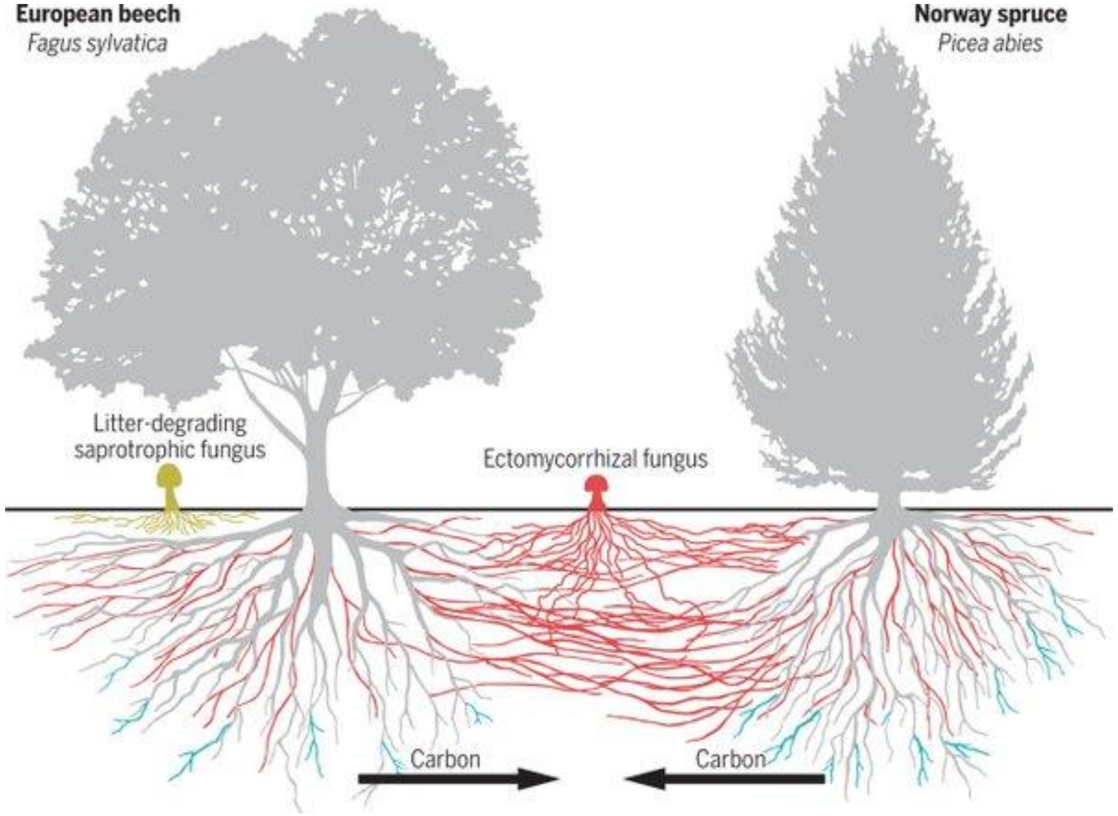
Common mycorrhizal networks (CMNs)

Mycelial connection between several co-existing plant individuals, even from different species

- Pathogen resistance
- Establishment of seedlings
- Amplification or alleviation of nutrient competition
- Impacts on plant community composition



Van der Heijden M (2016) Underground networking. Science (80-) 352:288–290. https://doi.org/10.1126/science.aaf3354

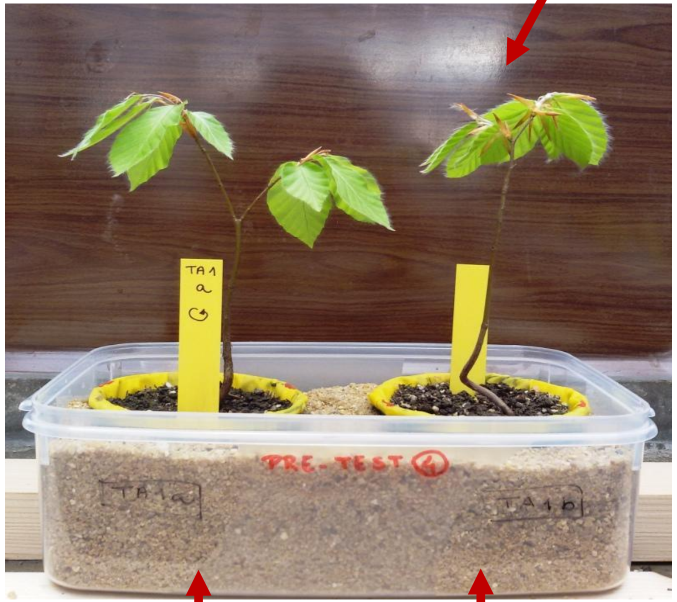
(1) Is the total belowground C allocation of plant photosynthates influenced by the size of the mycorrhizal network and its access to resources?

(2) Is the belowground C distribution within a CMN altered if trees have unequal access to C from photosynthesis?

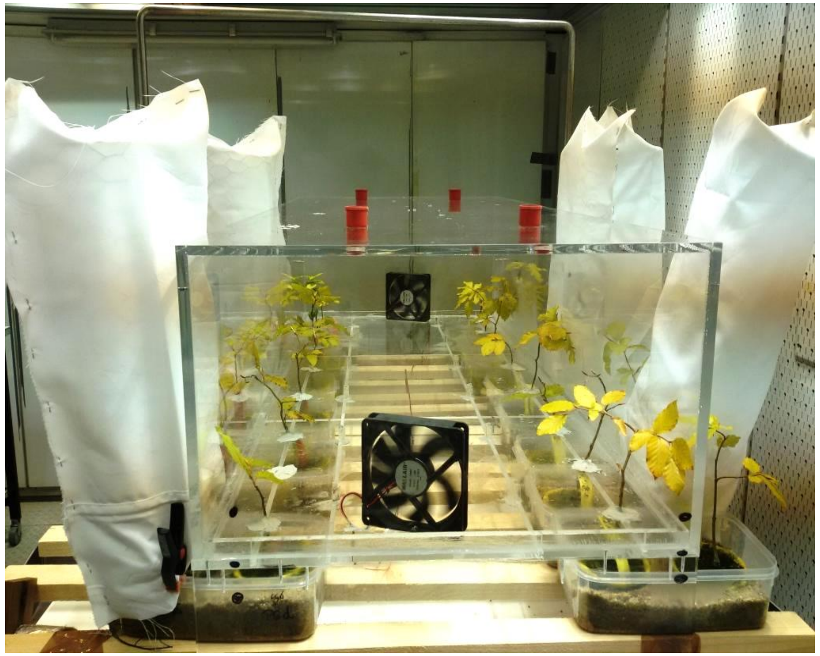
(3) Do CMNs amplify or alleviate competition for nutrients between connected trees?

Receiver **Donor**

^{13}C-CO_2



^{15}N - peat **^{15}N - peat**



^{13}C-CO_2 labelling chamber

Treatments:

+ CMN + shading
+ CMN - shading

- CMN + shading
- CMN - shading

Shading: 5 months
- CMN: pots rotated 360° every 2 days

Experimental setup

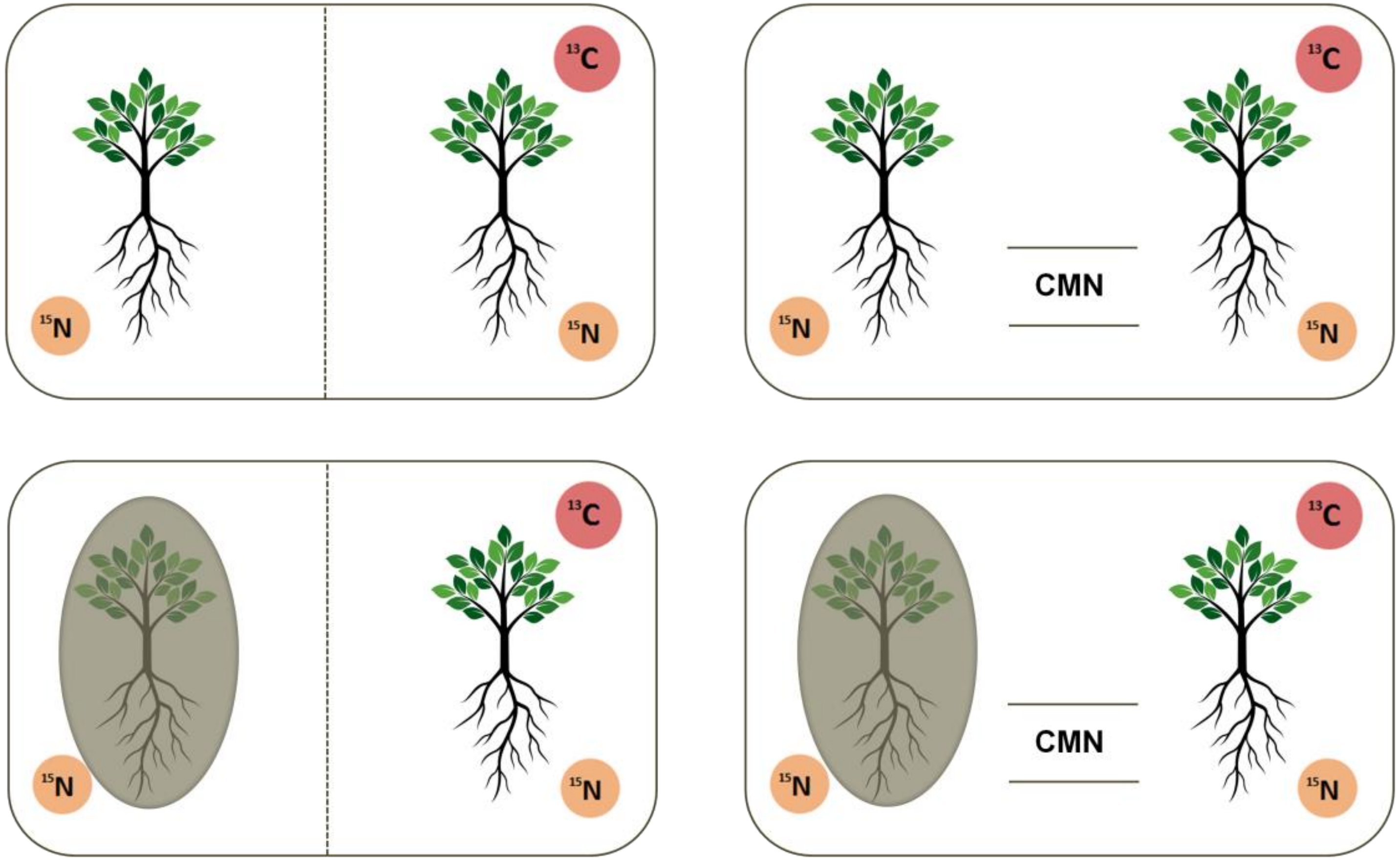
^{15}N labelled peat in a mycorrhiza-exclusive double layer mesh bag

3 cm

6 cm

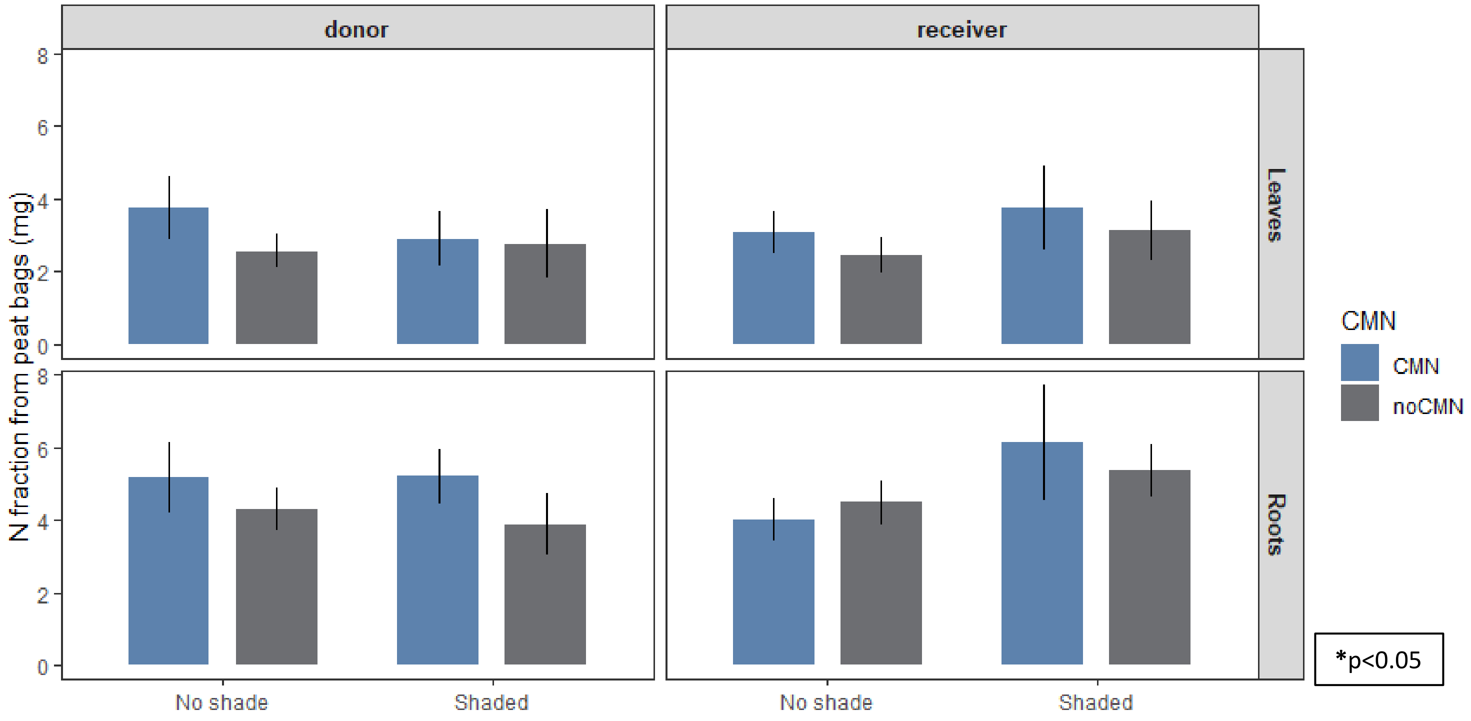
Without CMN

With CMN



(60 plants -> 4 treatments x 6 replicates + 2 treatments x 3 replicates)

Plants relied mostly on their mycorrhizal partners to acquire nitrogen



*p<0.05

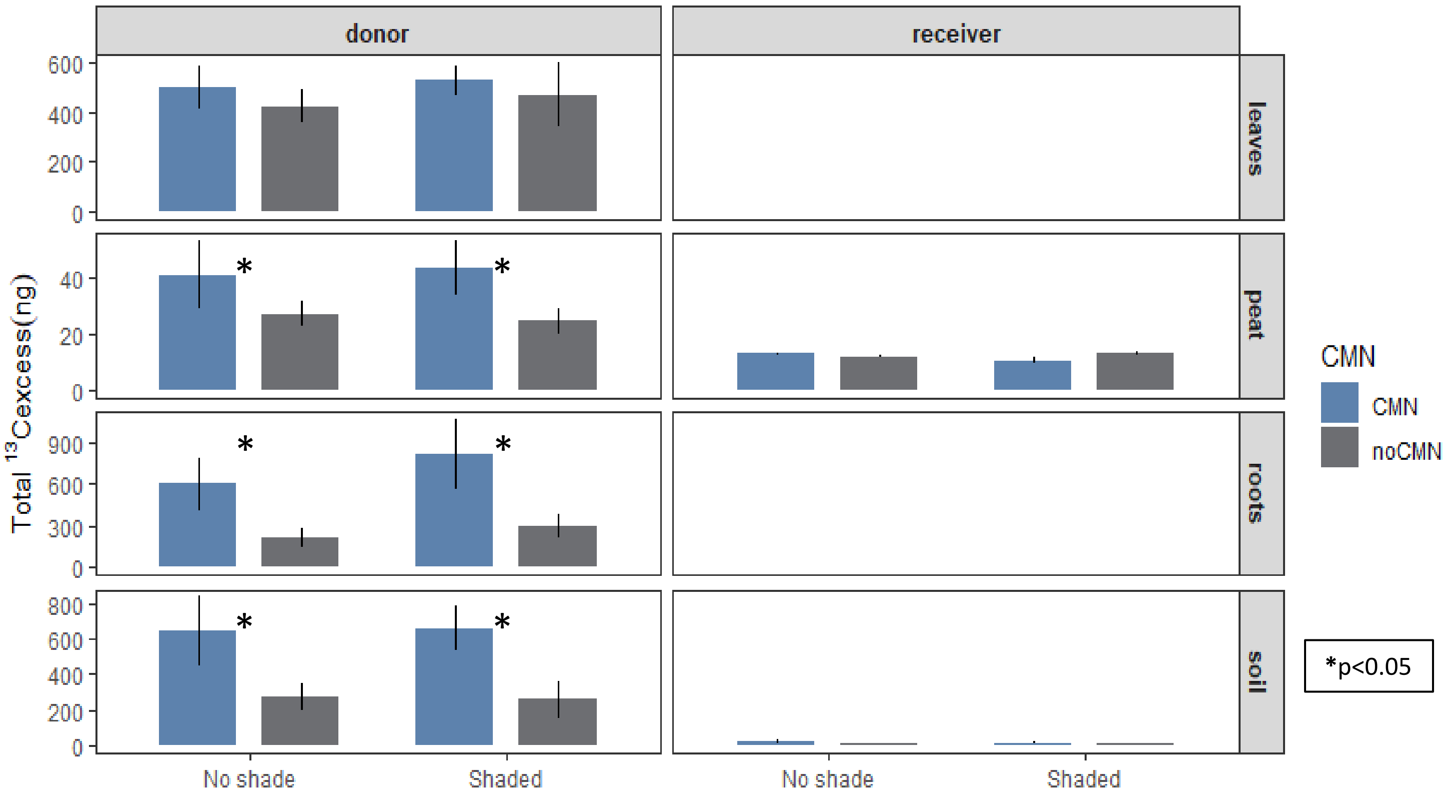
Two-pool mixing model:

63% of plant ^{15}N derived from hyphal-exclusive peat bags while only **37%** originated from the soil

- No clear effect caused by shading nor extended mycorrhizal network on N uptake

Results by ANOVA, calculated based on Two-pool mixing model. Error bars represent standard error; n = 6 for shaded and n=9 for not shaded treatments

CMN increased total assimilation and belowground transfer of C



Shading did not effect the transfer of ^{13}C

Differences in pools were analyzed with ANOVA. n = 6 for shaded and n=9 for not shaded treatments.
Error bars represent standard error.

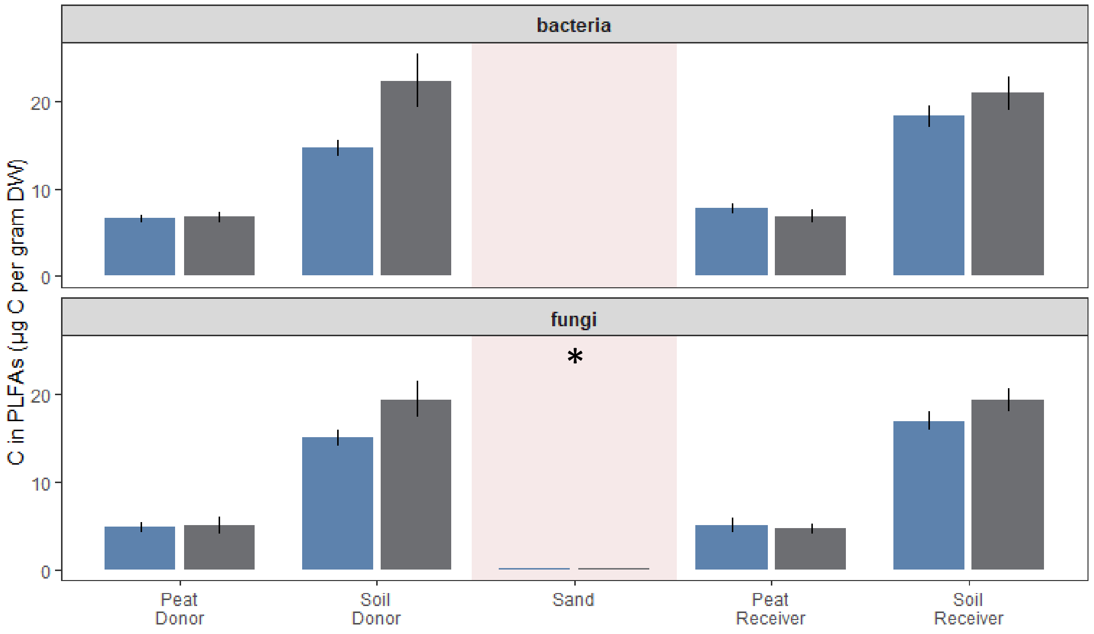
+CMN increased assimilation and belowground transfer of ^{13}C by donors

(ng excess ^{13}C)	Donor	Receiver
+CMN	1885	31
-CMN	956	21

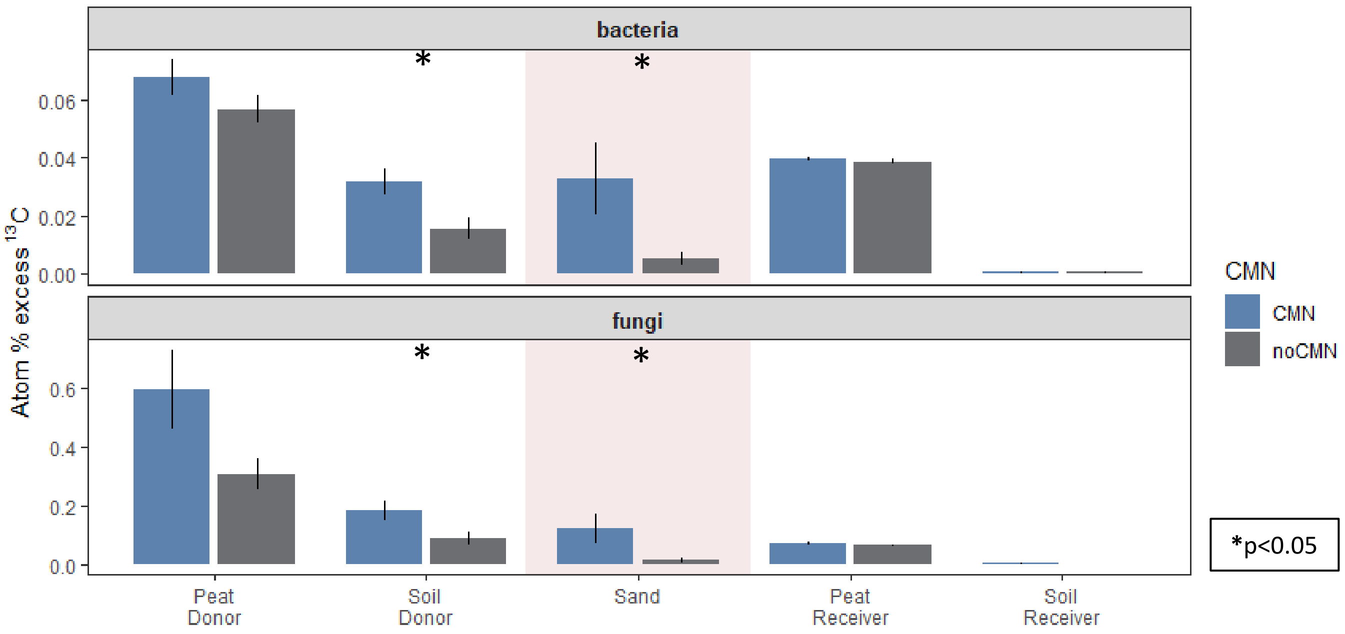
Preferential ^{13}C allocation to hyphal exclusive peat bags

(ng excess ^{13}C/g DW)	Donor	Receiver
Peat bags	15.06	5.08
Soil	8.63	1.25

C in the microbial biomass



^{13}C in the microbial biomass



Soil: Higher microbial biomass in soil than other pools, however, receivers were **not** significantly enriched in ^{13}C

Peat: High ^{13}C within microbes from **donor and receiver** peat bags, especially **fungal** markers

Sand: Disrupted CMN significantly decreased abundance of fungal markers. CMN affected bacterial and fungal ^{13}C enrichment

Differences in pools were analyzed with Kruskal-Wallis rank sum test. Significant tests ($p < 0.05$) were followed by Wilcoxon signed-rank's post-hoc test of multiple comparisons with Benjamini-Hochberg correction (adj. $p < 0.05$); n = 15. Error bars represent standard error.

Summary

(1) Is the total belowground C allocation of plant photosynthates influenced by the size of the mycorrhizal network and its access to resources?

- Yes: presence a larger mycorrhizal network connecting to another plant and an additional N source almost doubled photosynthetic CO_2 assimilation and belowground C allocation by plants
- However, ^{13}C was similarly transferred in the intact and disrupted CMN treatments to the neighboring pots (despite the fact that disrupted CMN treatments showed a decline in fungal biomass in the sand).

(2) Is the belowground C distribution within a CMN altered if trees have unequal access to C from photosynthesis?

- No: shading did not affect the belowground distribution of C.
- Plant C was preferentially transferred to mycorrhiza-exclusive N sources from the own and distant partner pot

(3) Do CMNs amplify or alleviate competition for nutrients between connected trees?

- No clear effects of belowground competition for N
- Plants relied mostly on the mycorrhizal fungi to acquire N

Conclusions

- Belowground ectomycorrhizal networks represent a significant sink strength for plant photosynthates and may thus be a major driver of C sequestration in beech forest soils.

- The belowground distribution of C via fungal networks is mainly related to the distribution of nutrient-rich patches in the soil and less to differences in the photosynthetic capacity of the host plants.