Investigating the transfer of carbon between trees via common mycorrhizal networks

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Introduction

Almost all plants have symbiotic mycorrhizal relationships with fungi. Plants transfer carbon (C) they fix from the atmosphere during photosynthesis to the fungi, in exchange for nutrients and water. The fungi has access to nutrients within a huge volume of soil, due to the extent of its vast hyphal network which far exceeds that of the tree roots. By trading these resources, both organisms benefit and this increases their chances of surviving. The fungal hyphae also add to belowground carbon storage by exuding carbon-containing compounds into the soil. A common mycorrhizal network (CMN) describes a situation when the fungal network links plants together belowground. These networks are also used by plants for communicating the presence of pests and diseases by releasing chemicals. This provides plants with a competitive advantage over other non-mycorrhizal plants and is referred to often as the Wood Wide Web (Figure 1).

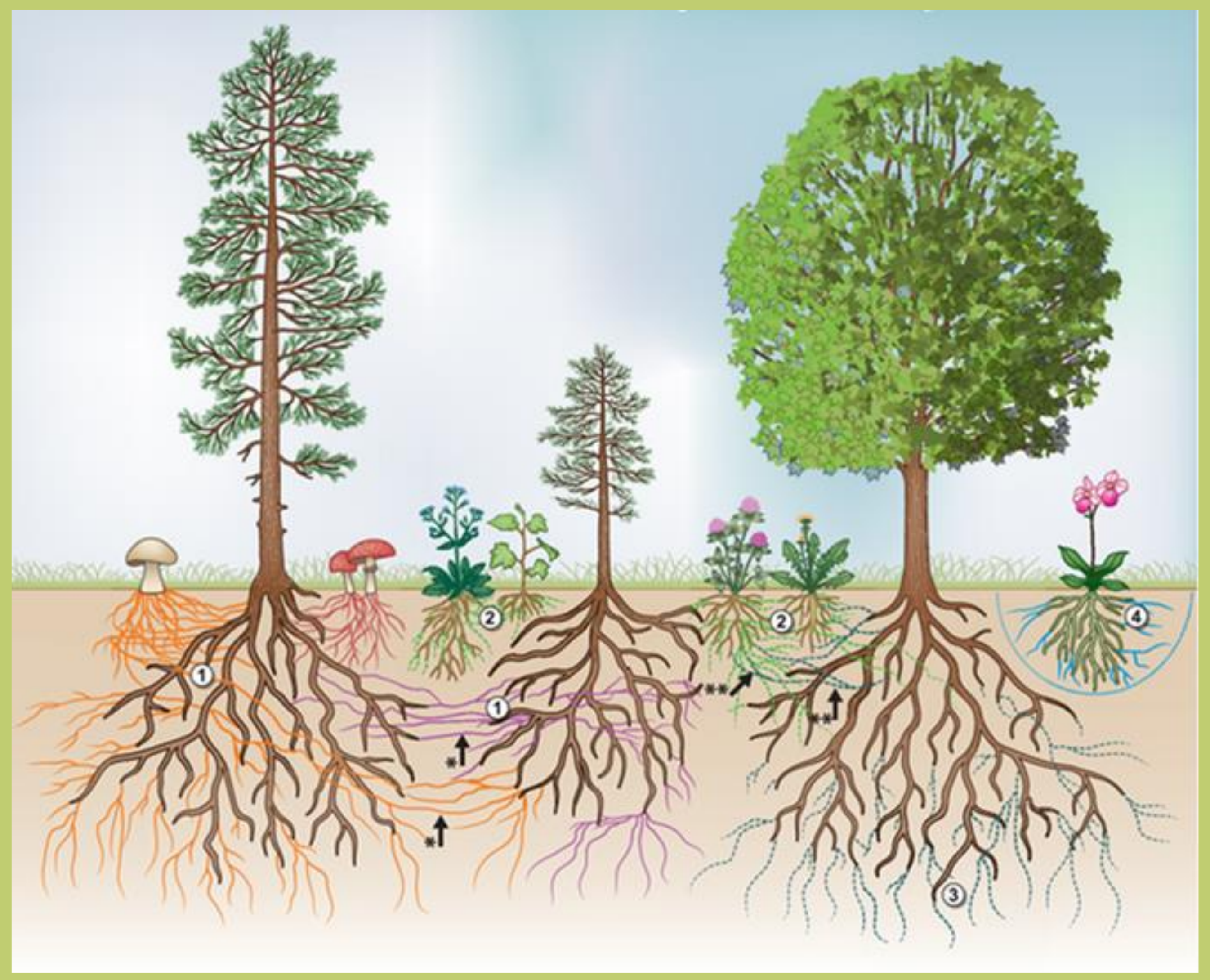

Figure 1: Common mycorrhizal network in a forest (van der Heijden et al, 2015)

Objectives

This experiment examines how C transfer via CMNs differs between three tree species with contrasting functional traits. The three trees selected for this study were Tree A: common alder (*Alnus glutinosa*), Tree B silver birch (*Betula pendula*) and Tree C sweet chestnut (*Castanea sativa*). By using combinations of the three tree species this experiment will quantify both inter and intra specific transfer.

Methods

We grew four trees of the three different species, in 10 litre pots connected by Perspex tubes (Figure 2) and covered the ends of the tubes in 40 µm nylon screen to prevent root ingress. We inserted mini-rhizon® suction sampling devices and respiration traps into the pots and arranged them in a randomised block design (Figure 3) in the following combinations:

4 x A-A, 4 x B-B, 4 x C-C, 4 x A-B, 4 x A-C, 4x B-C

We filled each interconnecting pipe with 2 kg of sand mixed with 20g of bone-meal and covered the pipe ends with 40 µm screen which excludes roots but allow hyphae through. One tree of the two trees was pulse-labelled with C^{14} carbon isotope and then the rate and quantity of C transfer, was measured by destructive harvesting, oxidising the sample and then using a scintillation counter to determine isotopic activity of each of the plant components.

Figure 2: The trees in the joined pots B (*Betula pendula*) on the left and C (*Castanea sativa*) on the right

Figure 3: The experiment in the greenhouse arranged in a random block design with controls

Preliminary results

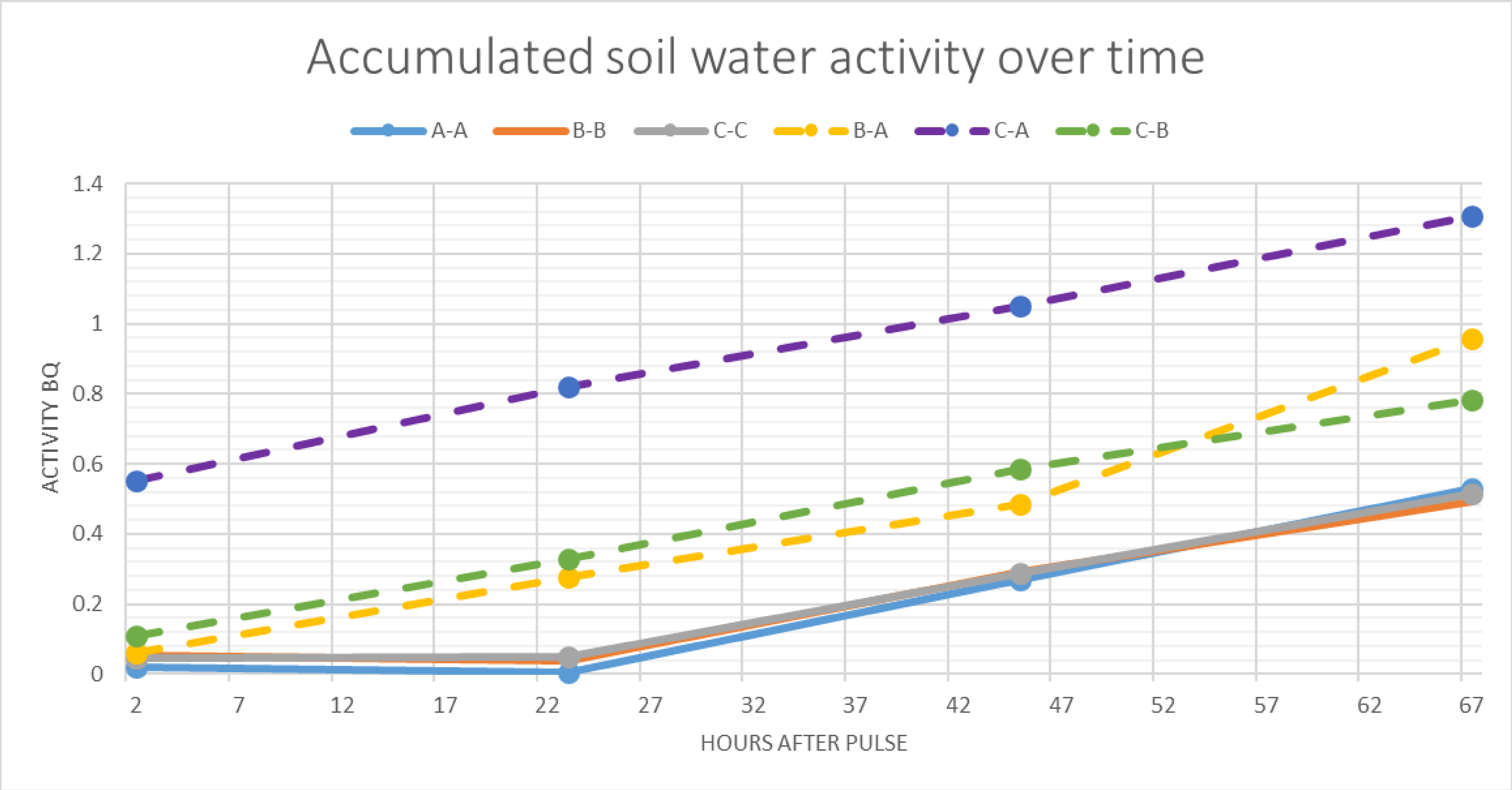

Figure 4: Initial results showing radioacitivity (Bq) of soil water in the non-pulsed tree collected via Rhizon suction samplers and plotted over time. Significant differences can be seen in the speed of C transfer between the inter (dotted lines) and intra-specific (solid line) plant combinations (p=<0.5).

Discussion and Conclusions

Although not all the samples from this experiment have been analysed initial results indicate that there is significantly more transfer of recently captured carbon between trees of different species. This cannot be fully confirmed until the radioactivity of each of the biological material samples has been counted, but is supported by experiments that investigate the sink source relationship that mediates the transfer process (Fellbaum *et al*., 2014) It If this does prove to be the case then this could have exciting implications in how we select species within carbon off-setting afforestation projects.

Literature cited

Fellbaum, C.R., Mensah, J.A., Cloos, A.J., Strahan, G.E., Pfeffer, P.E., Kiers, E.T. and Bücking, H., 2014. Fungal nutrient allocation in common mycorrhizal networks is regulated by the carbon source strength of individual host plants. *New Phytologist*, *203*(2), pp.646-656.

Heijden, M.G., Martin, F.M., Selosse, M.A. and Sanders, I.R., 2015. Mycorrhizal ecology and evolution: the past, the present, and the future. New Phytologist, 205(4), pp.1406-1423.

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