Sticky Roots Change Rhizodeposition Quality and Quantity Leading to Variable Disruption of Mineral-Organic Associations

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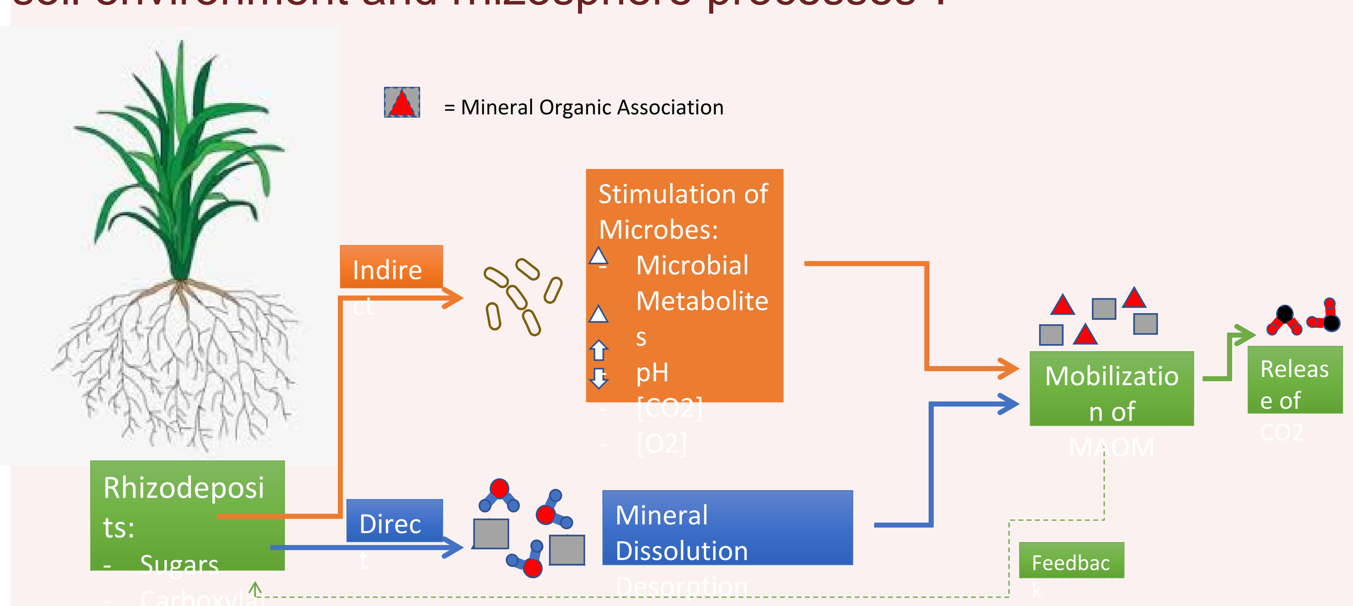
Introduction

As carbon levels continue to rise in our current climate, scientists are looking towards mechanistic approaches to improve carbon storage in the soil environment by understanding and applying strategies of carbon sequestration[1]. Terrestrial ecosystems are the third largest carbon reservoir with soils containing more than twice the amount of carbon in the atmosphere[2]. Much of that carbon is contained in the upper horizon where 90% of total organic carbon is stably bound through mineral organic associations(MOA)[3]. Due to this stability, MOAs are quantitatively the most important form of carbon protection in deeper soils[4]. The upper horizon contains the rhizosphere where much of the mineral-OM interactions are mediated through root processes, via the production of root exudates through rhizodeposition. These interactions are driven by the priming effect, in which root exudates act as signaling molecules driving microbial activity and the breakdown of MOA[5]. Our goal is to understand if and how changing rhizodeposition drives the release of carbon derived MOA and the processes in which it does this, via microbial activity or direct compound interaction. Understanding long term carbon storage mechanisms will lead to improved carbon models through a better comprehension of carbon sequestration via the soil environment and rhizosphere processes[6].



Objective

The objective of this project is to understand the mechanistic role in which a changing rhizodeposition, using infected roots, mediates the breakdown of mineral organic association through direct and indirect interactions, in addition to understanding how much carbon is then respired or assimilated into the microbial biomass.

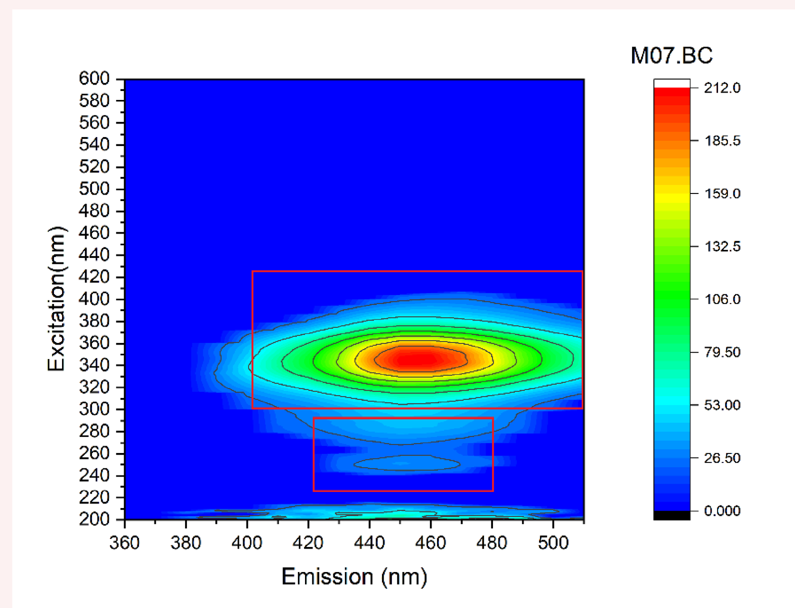
Hypothesis

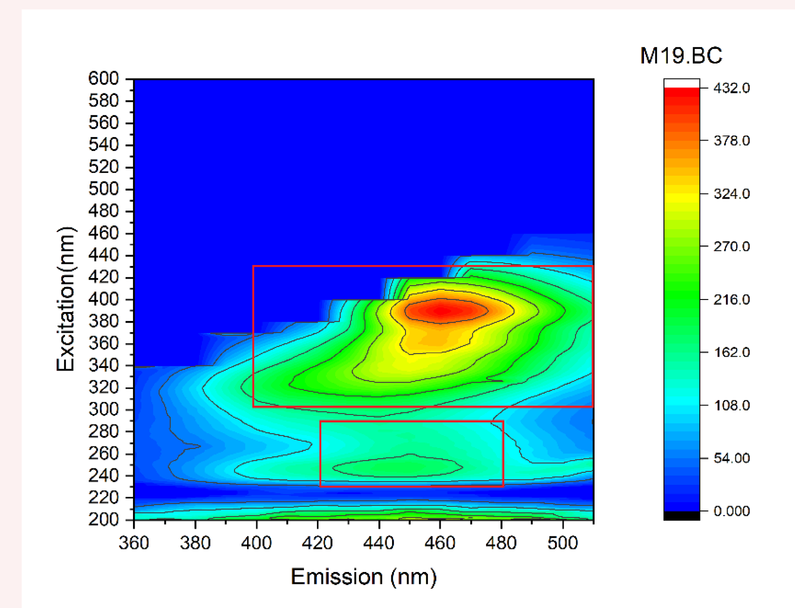
The infected roots will lead to higher rhizodeposition per biomass in which energetically favorable microbial products are produced, driving an increase in respiration of carbon derived MOA.

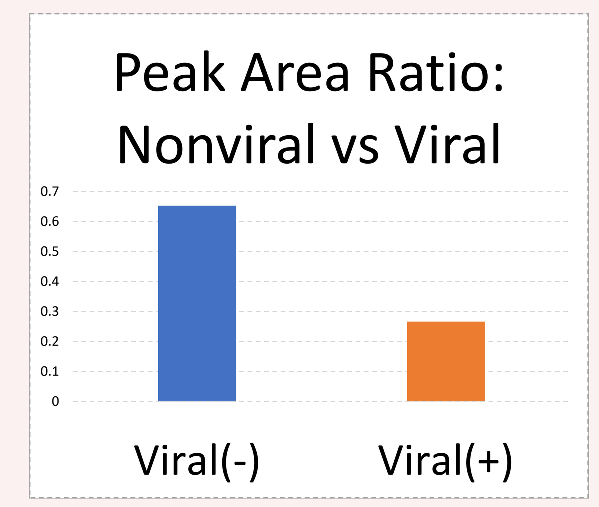
Approach

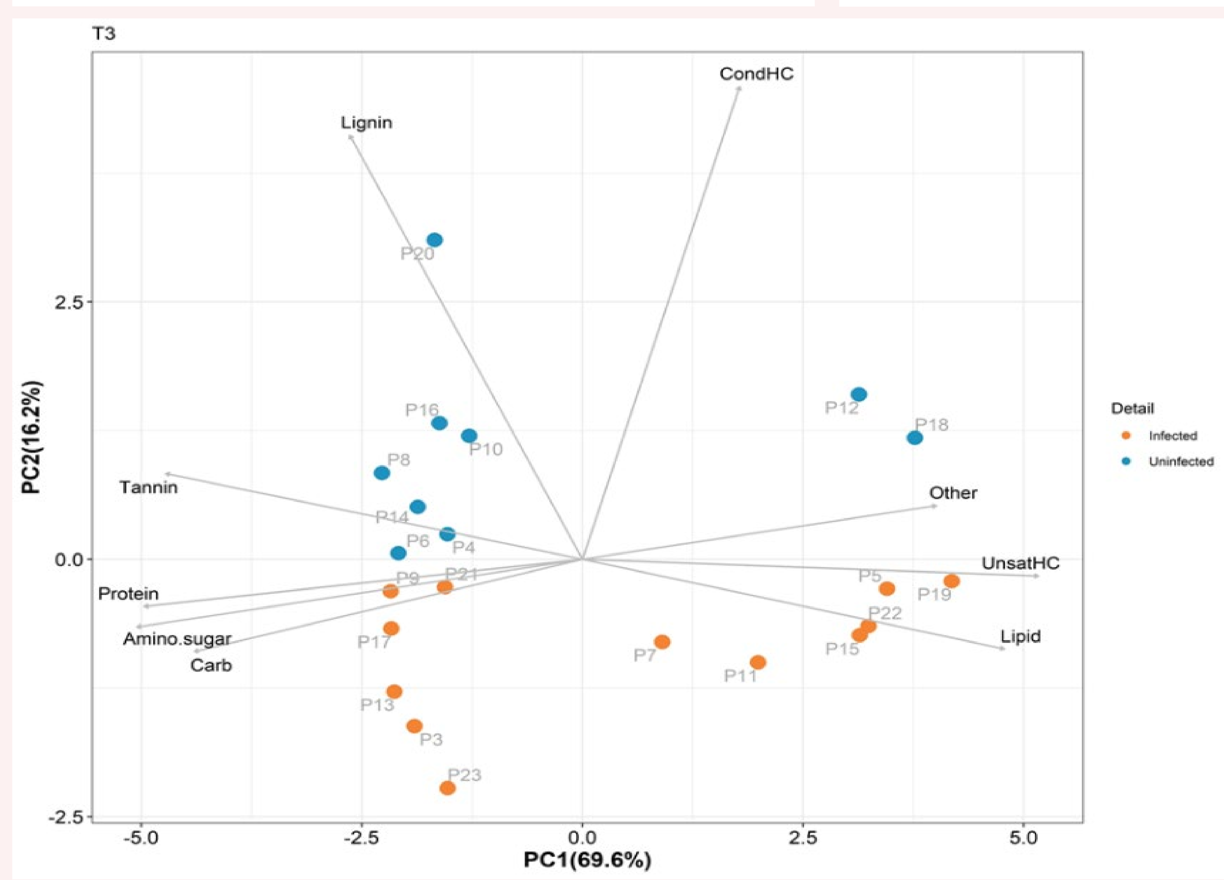
With the use of virally infected roots, we were able to produce a change in rhizodeposition with the hopes of altering the mechanism in which MOA degrades. Plants were grown in a hydroponics set-up in order to collect the rhizodeposits. The hydroponics solution was then transferred to a microcosm that contained ^{13}C sorbed onto minerals in order to later measure the carbon that had derived from MOAs along with the total carbon that has been respired in the system.

Quality of Rhizodeposition



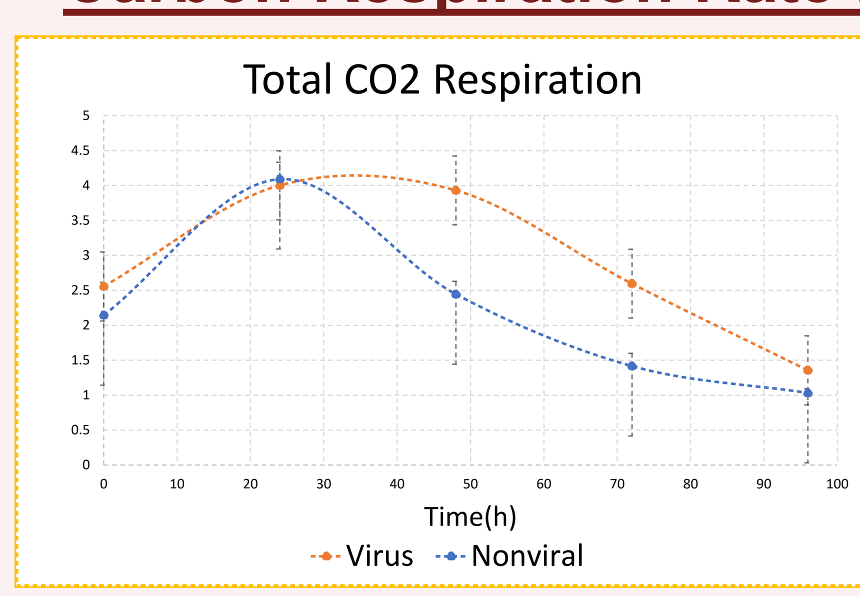


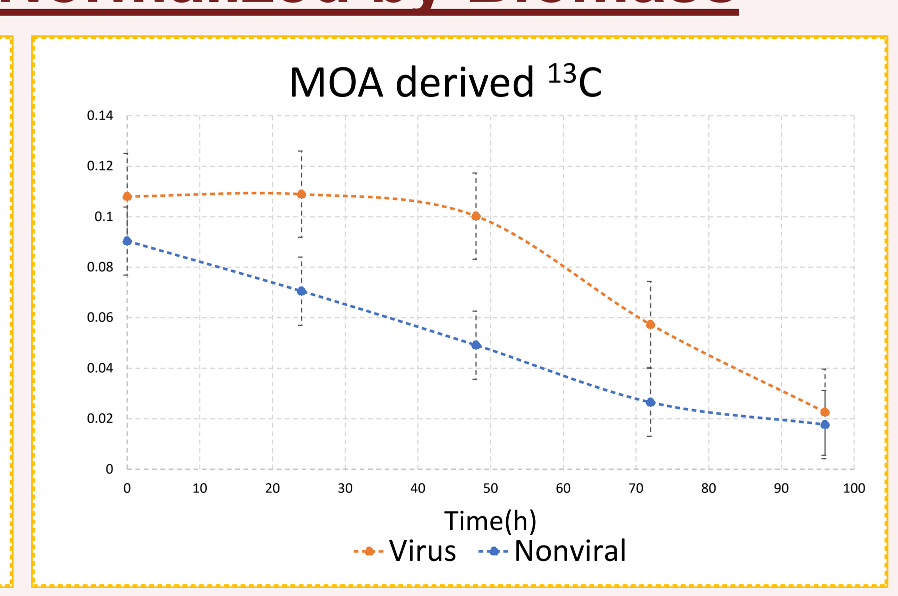


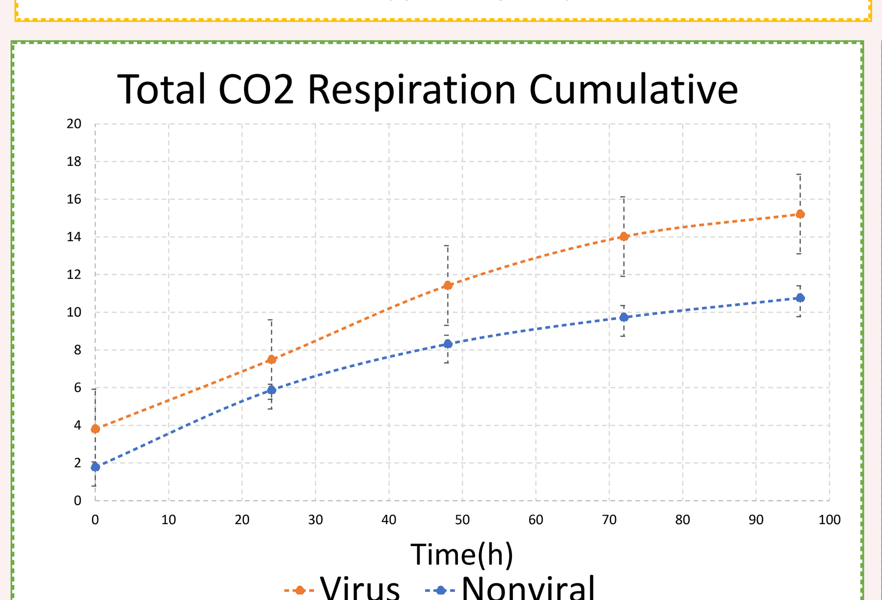


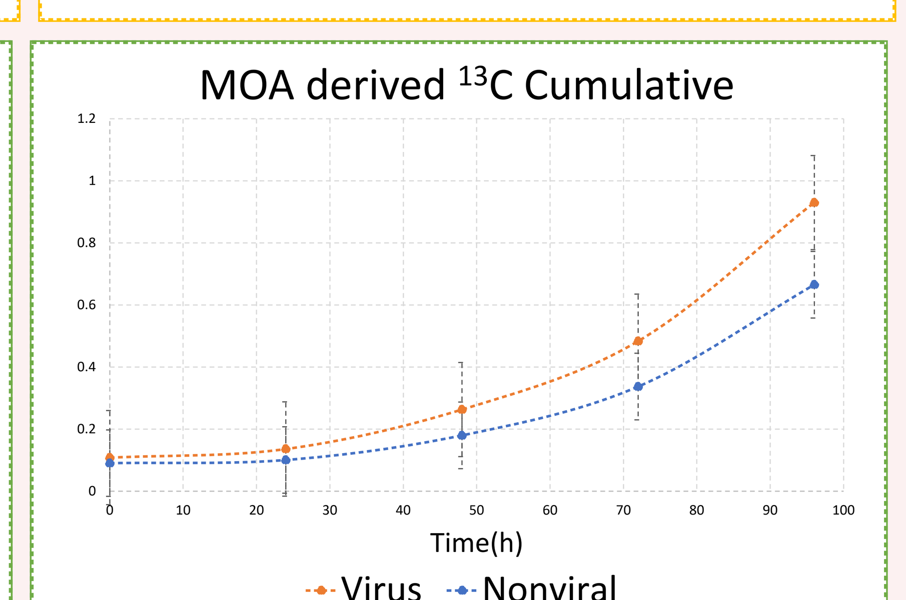
- Excitation Emission Matrices(EEMs) were used to show qualitative differences in sample types based on peak intensity. Changes in EEM shape can indicate a change in the characteristics or source of carbon[7].
- Note the shift in max excitation intensity between the infected and noninfected peaks. The shift in peak placement, shape and fluorescence intensity ratio indicates a change in compound characteristics between infected and noninfected rhizodeposits.
- FTICR-MS were used to identify compound types. Viral rhizodeposits contained more sugar-like compounds, while nonviral were more similar to lignin.

Carbon Respiration Rate Normalized by Biomass









- Respiration was normalized by biomass to show the difference in respiration between viral and nonviral samples
- Peak respiration in viral samples occurs later and leads to a less dramatic decline. This could be due to the stimulation of microbial activity.
- In the cumulative results, both total respiration and MOA carbon were higher in the viral samples than in the nonviral.

Conclusion

- There is a distinct difference in the chemical composition of the viral and nonviral rhizodeposits evident from both EEMs and FTICR-MS.
- There was a clear difference in which the respiration peak occurred for viral and nonviral samples. The later peak in the viral samples is strong evidence that the degradation of MOA is happening indirectly through microbes.
- Infected roots rhizodeposits are leading to a more long-lasting response due to the stimulation of microbial activity.
- In both the cumulative graphs respiration was higher in infected roots when normalized by biomass. An explanation for this may involve the longer lasting response from the microbial activity in the indirect pathway.

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