Soil Water Retention curve and Hydraulic Conductivity of Fungi-Treated Sand

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Abstract

Filamentous fungi in soil branch hyphae through pores, creating an interconnected fiber network, which is known as mycelium. Fungal mycelium can cross-link and entangle soil particles, which alters soil pore structures. Fungi can also secret hydrophobic compounds, changing the water wettability of soils. These fungal traits can affect the hydraulic properties of soils. This study investigated the effect of fungi on soil water retention and hydraulic conductivity of the Ottawa 50/70 sand treated by a saprotrophic fungus, Trichoderma virens (commonly existing in soil). The soil water retention curve (SWRC) and hydraulic conductivity tests were performed on fungi-treated and untreated Ottawa 50/70 sand. Water repellency of fungi-treated sand was also assessed by measuring contact angles (between the water droplet and fungi on sand specimen) and water drop penetration time. The results of SWRC tests showed an approximate 6-fold increase of air entry suction in the fungi-treated sand, indicating the fungal treatment improved water retention capability. The increased air entry suction was attributed to the change of pore geometry due to mycelium network. A 2-fold reduction in hydraulic conductivity was observed in the fungi-treated sand when growing fungi for 10 days. The hydraulic conductivity reduction was attributed to the enhanced discontinuity of fluid channel by cross-linking and entangling mycelium network. Also, strong hydrophobicity of mycelium layer on the specimen surface contributed to the reduction of hydraulic conductivity. Scanning electron microscopy (SEM) imaging was conducted to assess the morphologies of sand matrix treated by fungi.

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AGU FALL MEETING
New Orleans, LA & Online Everywhere
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1 – Introduction

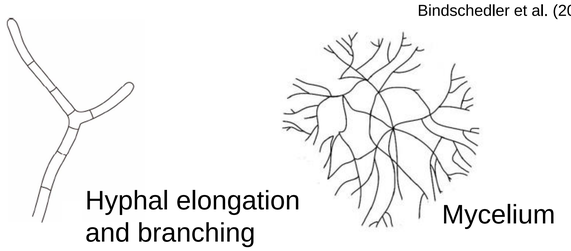
Research on bio-mediated soil improvement has focused on bio-mineralization (e.g., MICP), bio-gas generation, and biofilm accumulation using bacteria.

However, applications of fungal processes for soil improvement are relatively unexplored.

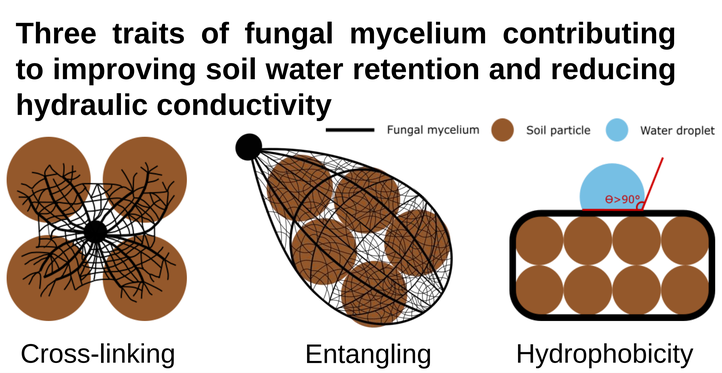
2 - Background

Fungal mycelium network

Bindschedler et al. (2016)



Three traits of fungal mycelium contributing to improving soil water retention and reducing hydraulic conductivity



3 – Research Goal and Tasks

Research Goal

Investigation of the effect of fungal mycelium on soil water retention curve and hydraulic conductivity of sand.

Tasks

1. Water repellency
2. Soil water retention curve (SWRC)
3. Hydraulic conductivity
4. SEM imaging

4 – Materials

- Fungi – *Trichoderma virens*

(Commonly existing in soil and not harmful to human)

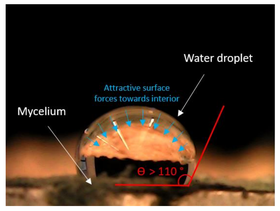
- Sand – Ottawa 50/70 sand
- Nutrition solution – Potato Dextrose Broth

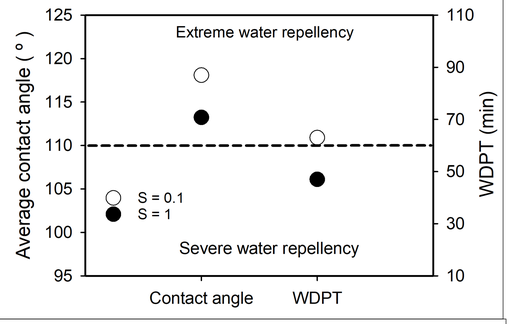
Fungi-treated sand

5 – Test Results

Water Repellency

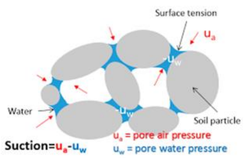
- Contact angle
- Water drop penetration time (WDPT)



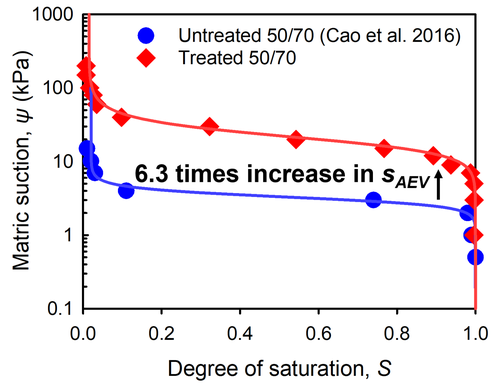


Soil Water Retention Curve

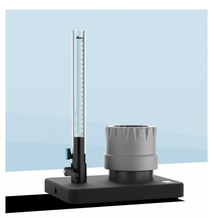
$$\psi = u_a - u_w$$



Chen (2020)



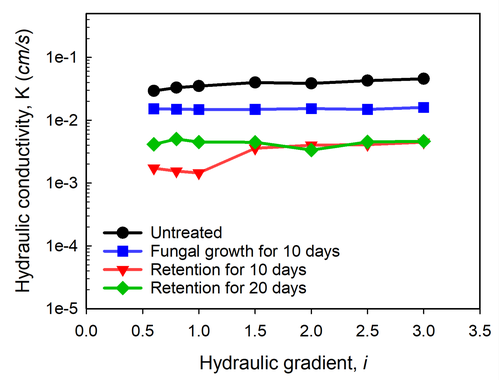
Hydraulic Conductivity



after growth for *10 days*

after *retention for 10 days*

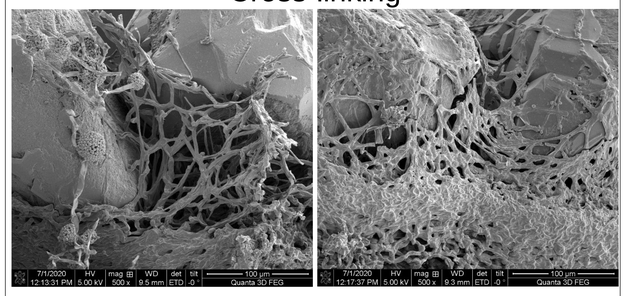
after *retention for 20 days*



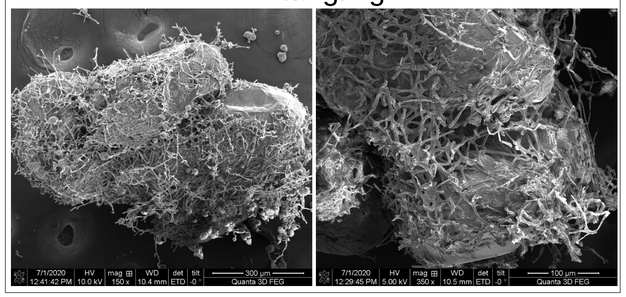
5 - Test Results (Continued)

SEM Images

Cross-linking



Entangling



6 - Conclusion

1. Fungal mycelium changed sand to be extremely or severely water repellent.
2. Fungal mycelium modified pore structure of sand, improving soil water retention with 6.3 times increase of air entry suction.
3. Fungal mycelium reduced hydraulic conductivity up to 25 times.
4. SEM images clearly captured mycelium cross-linking and entangling sand particles.

Acknowledgement

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