Master Thesis

How Plants and Mycorrhizal Fungi Contribute to Soil Aggregate Stability

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Summary

Bioengineering measures to improve soil stability in landslide areas are widely investigated and have been improved over the years. But the measures are complex and it is a major challenge to perform adequate assessments of the measures. Besides technical measures, biological measures are also applied to protect the slopes against landslides. The main goal is to increase soil aggregate stability with a sustainable vegetation cover. Therefore, a knowledge about the soil and the vegetation is essential. In particular, mycorrhizal plant-fungus associations play a crucial role within bioengineering measures. Mycorrhizal fungi may increase plant growth which consequently influences soil aggregate stability. This is the research field of this Master's thesis.

The thesis is embedded in a research project of the WSL Institute for Snow and Avalanche Research (SLF) under the National Research Program (NRP) "Sustainable use of soil as a resource" and aims to quantify the effects of plants and mycorrhizal fungi on soil aggregate stability. Therefore, a pot experiment was designed using two different plant species. The soil material originated from the landslide area Schwandruebi which is situated in the municipality Dallenwil in the Swiss canton Nidwalden. The tree species *Alnus incana* (A) and the grass species *Poa pratensis* (P) were considered separately and in combination (AP), either inoculated with mycorrhizal fungi (M) or non-inoculated. Additionally, two control treatments inoculated (KM) or not (K) were added to the experiment. For each of the eight treatments 13 replicates were produced, resulting in a total number of 104 samples. After a growing period of 17 weeks, wet-sieving and soil aggregate stability tests were performed. During the wet-sieving, the pore water pressure was continuously measured using a high suction tensiometer. The soil was further analysed by an Ergosterol liquid phase extraction. After the staining of mycorrhized roots, the degree of mycorrhization was determined using a modified gridline intersect method. Further, all root systems were cleared of soil particles and the root length was measured with the root length scanning software WinRhizo. Statistical analysis was performed using the Kruskal-Wallis and pairwise Wilcoxon rank sum tests.

Obtained results of the tensiometer measurements showed in general a lower initial pore water pressure and a steeper curve during the wetting in mycorrhized treatments compared to non-mycorrhized treatments. With respect to the soil aggregate stability, planted treatments revealed significantly higher stabilities than the control treatments. Additionally, a significant negative effect of mycorrhized planted treatments on soil aggregate stability was observed compared to the corresponding non-mycorrhized treatments. Regarding the Ergosterol liquid phase extraction, no Ergosterol could be measured. Further, ectomycorrhizas were present on the roots of *Alnus incana* but no arbuscular mycorrhizas could be identified in the root systems of *Poa pratensis*. Considering the root analysis, treatments of *Alnus incana* (A, AM) yielded a significantly lower root length per soil volume compared to the treatments

of *Poa pratensis* (P, PM) and the combined treatments (AP, APM). Additionally, the root lengths of all mycorrhized treatments were lower compared to the corresponding non-mycorrhized treatments. Similar findings were observed with respect to the root dry weight. In contrast, aboveground plant dry weight resulted in significantly higher values in mycorrhized treatments which included *Alnus incana* compared to the corresponding non-mycorrhized treatments. The total amount of biomass was affected in the same way but differences were not significant in most cases.

In conclusion, soil aggregate stability was significantly higher in planted treatments compared to the control treatments but mycorrhized treatments did not positively affect the stability. In terms of the total amount of biomass, only mycorrhized treatments which included *Alnus incana* produced more biomass than the corresponding non-mycorrhized treatments. The effects on soil aggregate stability may be attributed to the lower initial water content in mycorrhized treatments compared to non-mycorrhized treatments. Additionally, the high soil dry unit weight might have hampered root growth and disabled a mycorrhization of *Poa pratensis*. Further, the increased aboveground biomass and decreased root growth may be the results of an excessive fertilizer application.

The investigations were slightly limited by the lack of mycorrhization within the treatments of *Poa pratensis*. Therefore, this plant-fungus association is questioned with respect to an application in bioengineering measures. However, the present thesis enhances the knowledge in terms of this new plant-fungus association. Additionally, the thesis makes noteworthy contributions to the understanding of pore water pressure measurements in small soil samples during wet-sieving using a high suction tensiometer. Nevertheless, further research regarding the pore water pressure and the plant-fungus association is strongly recommended. In particular, pore water pressure measurements using soil samples with similar initial water content values may result in meaningful observations.