Geophysical Research Abstracts
Vol. 20, EGU2018-8810, 2018
EGU General Assembly 2018

Linking root growth dynamics to erosion protection, aggregate stability and carbon sequestration in 12 herbaceous species used for revegetation of road embankments

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Hard engineering structures are costly in terms of economy, environmental impact and carbon consumption. We argue that in an era of industrialization and urbanization knowledge should be developed on how to use vegetation in geo-infrastructures to improve direct benefits (e.g. erosion control) alongside other indirect ecosystem services, such as enhancing soil health or carbon (C) storage. Therefore, we are investigating the potential of 12 herbaceous species with regard to erosion protection, soil aggregate stability and C sequestration. These species are commonly planted on road embankments in the south of France, and we aim to propose new management plans for optimizing the use of vegetation and its services in geo-infrastructures. To investigate the influence of species on soil characteristics we examined root growth and functional traits. Each species was grown from seed in a monoculture in 72 inclined steel boxes (0.7 x 0.7 x 0.3 m) and every monoculture was replicated six times with additional six control (bare soil) boxes. Three of the replicates were used for soil sampling and C analysis. A further three replicate boxes were equipped with rhizotrons (PVC windows to observe root growth), and every month, the rhizotrons were scanned and images of roots were analyzed with the software SmartRoot© to determine diameter, volume and elongation. Every 4 months, aggregate stability tests were performed and C in different soil fractions was analyzed. Additionally, rainfall simulations were performed at two vegetation stages (seedling and mature). At the mature stage, simulations were performed before and after cutting the aerial biomass, to disentangle the effects of above- and belowground biomass and relate results to root properties. Also, runoff and sediments were collected after each natural rainfall. Results showed that species from the Fabaceae family were more efficient at controlling erosion and increasing infiltration rates compared to members of the Poaceae family. However, a significant effect of species or family was not found with regard to aggregate stability. Root development was initially greater for Poaceae species; however, after the fourth month (start of March 2017) Fabaceae species boosted their root production and root elongation rate increased significantly, resulting in a greater root volume compared to the Poaceae. Sequestered C did not change significantly in the first four months of growth, however Fabaceae species tended to transport more carbon into the soil likely due to their greater root development. These results suggest that erosion and infiltration processes are rapidly influenced by vegetation biomass and plant traits, whilst the development of soil aggregate stability and C sequestration are longer-term processes. Therefore, we suggest that herbaceous species of the Fabaceae family have a major potential for rapidly improving soil structure on road embankments, and further studies are being performed to investigate this result.