
Effects of Bending Stiffness on the Pull-Out of Model Roots

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Abstract

Roots anchorage onto soil is one of the most essential functions of plant roots. Although there have been many reports on root-soil interactions and root anchorage for individual plants, few studies have focused on the effects of mechanical or geometrical parameters. In this study, we performed pull-out experiments using 3D-printed branched roots with various stiffness and diameters out of the soil at a constant velocity. Consequently, we found that the geometry and the bending stiffness of the root significantly affected the pull-out performance. We developed a theoretical model describing the pull-out behavior and successfully calculated maximum pull-out forces in reasonable agreement with experiments. Our results suggest that the bending deformation of the roots and friction or fracture of the soil determine the pull-out behavior and that the pull-out forces can be estimated using a simple theoretical model.

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