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Tree Resistance to Wind Storm: The Effects of Soil Saturation on Tree Anchorage of Young Pinus pinaster

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Abstract : Windstorm damage to European forests has ecological, social and economic consequences of major importance. Most trees during storms are uprooted. While a large amount of work has been done over the last decade on understanding the aerial tree response to turbulent wind flow, much less is known about the root-soil interface, and the impact of soil moisture and root-soil system fatiguing on tree uprooting. Anchorage strength is expected to be reduced by water-logging and heavy rain during storms due to soil strength decrease with soil water content. Our paper is focused on the maritime pine cultivated on sandy soil, as a representative species of the Forêt des Landes, the largest cultivated forest in Europe. This study aims at providing knowledge on the effects of soil saturation on root anchorage. Pulling experiments on trees were performed to characterize the resistance to wind by measuring the critical bending moment (Mc). Pulling tests were performed on 12 maritime pines of 13-years old for two unsaturated soil conditions that represent the soil conditions expected in winter when wind storms occur in France (w=11.46 to 23.34 % gg^{-1}). A magnetic field digitizing technique was used to characterize the three-dimensional architecture of root systems. The soil mechanical properties as function of soil water content were characterized by laboratory mechanical measurements as function of soil water content and soil porosity on remolded samples using direct shear tests at low confining pressure (< 15 kPa). Remarkably Mc did not depend on w but mainly on the root system morphology. We suggested that the importance of soil water conditions on tree anchorage depends on the tree size. This study gives a new insight on young tree anchorage: roots may sustain by themselves anchorage, whereas adhesion between roots and surrounding soil may be negligible in sandy soil.

Keywords : roots, sandy soil, shear strength, tree anchorage, unsaturated soil
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