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**Optimal design of artificial and real roots for water uptake** YEONSU JUNG, Seoul National University, KEUNHWAN PARK, Department of Physics, Technical University of Denmark, WONJUNG KIM, Department of Mechanical Engineering, Sogang University, HO-YOUNG KIM, Seoul National University — Water transport in the soil is more restricted than in the root xylem because the interstices of soil grains are smaller than the xylem conduits and the interfacial tension resists the meniscus movement. Extending root surface area alone, however, does not necessarily increase the water uptake efficiency when considering the costs of construction and maintenance of the roots and the competition among root fibers. Upon the basis of biological observation that most of cereal crops exhibit the volume density of root declining exponentially as a function of depth, we construct a theory for an optimal root density by modeling the mass transfer into root surface as heat flux around a fin. We verify our theory by comparing the optimal model with the biological observation and the data obtained from the experiments with an artificial root-inspired device. The device measures the water uptake rate of the channels of different lengths in a paper sheet, mimicking the roots in porous soil background. This study has practical implication in the optimal design of various transport networks as well as the agricultural industry.

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