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A hydrogel-soil system to enhance plant water uptake

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By 2030, a third of the population in developing countries will reside in areas where the gap between water demand and supply is predicted to be over 50%. Agriculture is responsible for over 71% of annual water withdrawals worldwide (currently ~ 3,100 billion m3 and predicted to be ~4,500 billion m3 by 2050). The amount of water held as groundwater is more than 100 times the amount collected in rivers and lakes. Globally, the per capita irrigated area has been decreasing for 30 years. Population growth and increased irrigation requirements have resulted in groundwater mining with a universal increase in water table depth.
A preliminary study aimed at developing a bioinspired pump capable of passively lifting subsurface water is presented. The bioinspired system uses emerging materials and concepts in geotechnical engineering to mimic the wicking mechanisms that plants use for transpiration. Upon droughts and dry periods, soil desaturates, its hydraulic conductivity drops and less water is made available to plants. As water inflow to the plant decreases, stomata close to stop transpiration and prevent plant dehydration, photosynthesis ceases, and plants wilt. Upon dry conditions, to delay soil desaturation, preserve a high hydraulic transmissivity and extract water for longer, plants secrete a gelatinous substance named mucilage around root tips. This naturally engineered "grout"fills the pore space by reducing the pore diameter and increasing the soil air-entry value (creating smaller capillaries).
A capillary network aimed at mimicking plant mucilage secretion is formed by the injection of colloidal silica-based hydrogel (CS) into the soil. It is shown that the presence of hydrogel enhances soil hydraulic conductivity and water retention capacity thus enabling better water uptake during periods of drought. A hydromechanical characterization of the hydrogel-soil system and preliminary experimental results of the hydrogel interaction with the roots of various species of shrubs will be presented.
Keywords: Colloidal silica hydrogel; plants; drought; capillary rise; roots

Participation

In-Person

References

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