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Influence of Plant Cover and Redistributing Rainfall on Green Roof Retention and Plant Drought Stress

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Abstract : Green roofs are a promising engineered ecosystem for reducing stormwater runoff and restoring vegetation cover in cities. Plants can contribute to rainfall retention by rapidly depleting water in the substrate; however, this increases the risk of plant drought stress. Green roof configurations, therefore, need to provide plants the opportunity to efficiently deplete the substrate but also avoid severe drought stress. This study used green roof modules placed in a rainout shelter during a six-month rainfall regime simulated in Melbourne, Australia. Rainfall was applied equally with an overhead irrigation system on each module. Aside from rainfall, modules were under natural climatic conditions, including temperature, wind, and radiation. A single species, Ficinia nodosa, was planted with five different treatments and three replicates of each treatment. In this experiment, we tested the impact of three plant cover treatments (0%, 50% and 100%) on rainfall retention and plant drought stress. We also installed two runoff zone treatments covering 50% of the substrate surface for additional modules with 0% and 50% plant cover to determine whether directing rainfall resources towards plant roots would reduce drought stress without impacting rainfall retention. The retention performance for the simulated rainfall events was measured, quantifying all components for hydrological performance and survival on green roofs. We found that evapotranspiration and rainfall retention were similar for modules with 50% and 100% plant cover. However, modules with 100% plant cover showed significantly higher plant drought stress. Therefore, planting at a lower cover/density reduced plant drought stress without jeopardizing rainfall retention performance. Installing runoff zones marginally reduced evapotranspiration and rainfall retention, but by approximately the same amount for modules with 0% and 50% plant cover. This indicates that reduced evaporation due to the installation of the runoff zones likely contributed to reduced evapotranspiration and rainfall retention. Further, runoff occurred from modules with runoff zones faster than those without, indicating that we created a faster pathway for water to enter and leave the substrate, which also likely contributed to lower overall evapotranspiration and retention. However, despite some loss in retention performance, modules with 50% plant cover installed with runoff zones showed significantly lower drought stress in plants compared to those without runoff zones. Overall, we suggest that reducing plant cover represents a simple means of optimizing green roof performance but creating runoff zones may reduce plant drought stress at the cost of reduced rainfall retention.

Keywords : green roof, plant cover, plant drought stress, rainfall retention
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