Title: Environmental and economic comparison between Capillary Hydroponic System and Variable Depth Rootzone to promote sustainable putting green management

Project Leaders:
Thomas A Nikolai, Ph.D. Michigan State University, Michael Rabe Michigan State University

Collaborators:
Wei Zhang, Ph.D. Michigan State University, Kevin Frank Ph.D. Michigan State University, and Brian Horgan, Ph.D. Michigan State University

Objectives:

1. Determine differences in the amount of irrigation water used between the Capillary Hydroponic System (CHS) and the Variable Depth Rootzones (VDR).
2. Determine the uniformity of soil moisture retention in the CHS and VDR.
3. Gather data including green speed, surface firmness, clipping yield, pest observations, nutrient holding capacity, organic matter build-up, and drainage water nutrient content.

Start Date: 2023
Project Duration: 2-years

Summary Points:

- CHS greens required significantly less irrigation than VDR.
- Weather conditions impact irrigation differences between the systems.
- The CHS and VDR resulted in insignificant differences regarding green speed, surface firmness, visual appearance, clipping yield, and organic matter content in the first year of the study.

Rationale

United States golf courses use approximately 2.27 trillion liters of water per year for irrigation and water cost is significant (e.g., $1,068/Million L in the pacific region) (Gelernter et al., 2015 Shaddox et al., 2022). The need for water conservation may be further amplified by climate change (Scott et al., 2018). Furthermore, turfgrass quality and playability of golf courses must be maintained or even improved when adopting any new water and nutrient conservation practices.

Methods and Materials

Christopher Wilczynski, American Society of Golf Course Architects, drafted 6 greens with identical undulations and slopes of 1.5, 3, and 5%. Each green was constructed 11 m x 11 m separated by a concave buffer zone 6 m wide east to west and 3.5 m wide north to south to negate the possibility of runoff or overhead irrigation drifting from one green to another. All six research greens were constructed with the same sand conforming to USGA specification.

The site was seeded with T1 creeping bentgrass (*Agrostis stolonifera*) on 15 June 2022 and was grown in with overhead irrigation. Construction included block style irrigation system with heads on each corner of each green. Each Capillary Hydroponic System (CHS) includes a waterproof liner divided into 2 equal sections with a 55-gallon control basin buried beside the

green connected to feed pipes that protrude to the middle of each section. The control system pumps water back and forth between sections every four hours and the control basin also houses a float valve that controls an adjustable water table. The Variable Depth Rootzone (VDR) greens diverges from United States Golf Association (USGA) recommendations by decreasing the rootzone depth at the top of slopes (8–10 inches) and increasing it in low lying areas (14-16 inches).

Maintenance practices include mowing six times per week at 3 mm, rolling 3 times per week, and sand topdressing and foliar fertility. The greens had sufficient density to initiate irrigation treatments on 21 June 2023.

Prior to study initiation irrigation triggers were determined by combining visual observations and volumetric moisture content (VMC) measurements with a TDR-350. Greens displayed visible wilting at 7% VMC, therefore 8%VMC became the irrigation trigger. VDR returned 80% relative daily evapotranspiration via overhead irrigation while CHS system was met by setting auto fill when the water table fell below 20 cm below the surface of the lowest spot (Figure 1). CHS greens only received overhead irrigation following sand topdressing, fertility, and fungicide applications receiving the same volume of irrigation as VDR on those occasions.

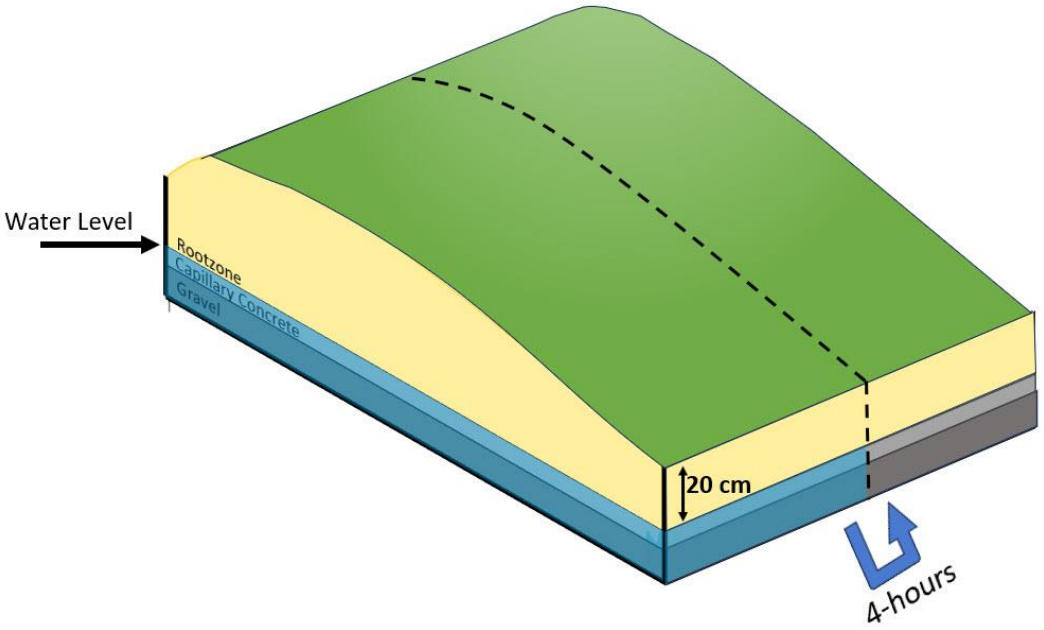

Figure 1 A cross section of the Capillary Hydroponic System

Each green was constructed with a drainage line and following significant rain events samples were collected and analyzed. When pests were observed data was collected and curative applications were made. Soil tests were conducted by collecting nine 19 mm diameter cores 7.5 cm deep and clippings yield was measured by drying and weighing clippings from a single pass with a Toro Flex 2100 in the identical location spanning elevation changes on each green.

Other data collection included green speed measurements with a USGA Stimpmeter, surface firmness on six locations on each green with a USGA TruFirm, volumetric moisture content

monitored weekly at two depths, 7.5 cm, and 20 cm, with a handheld TDR 350 across the greens surface in a 1.5 m x 1.5 m grid to map uniformity of water distribution.

Results to Date

CHS greens required 59% less irrigation water to prevent surface wilting compared to VDR greens during the summers of 2023 and 2024 (Figure 2). Within that time period two 11-day intervals in each year were selected to represent two weather conditions:

1. low precipitation (<0.15 cm) and high Relative Potential Evapotranspiration (RPET) (>0.30 cm) resulting in CHS greens needing 44% and 45% less irrigation than the VDR greens in 2023, and 2024 respectively.
2. high precipitation (>0.40 cm) and high RPET (>0.30 cm) resulting in CHS greens using 76% and 74% less irrigation than the VDR greens in 2023 and 2024 respectively.

There was no significant difference regarding soil chemical analysis or organic matter content, clipping yield, green speed, or surface firmness. In 2024 VDR greens displayed signs of localized dry spot (LDS) and required a wetting agent application. However, VDR consistently demonstrated a more uniform volumetric moisture content compared to the CHS and there were some differences in nutrient content in the drainage water, but more data is required to make any conclusions. While both systems were impacted by take all patch (*Gaeumannomyces graminis*) the take all patch was more persistent in the CHS.

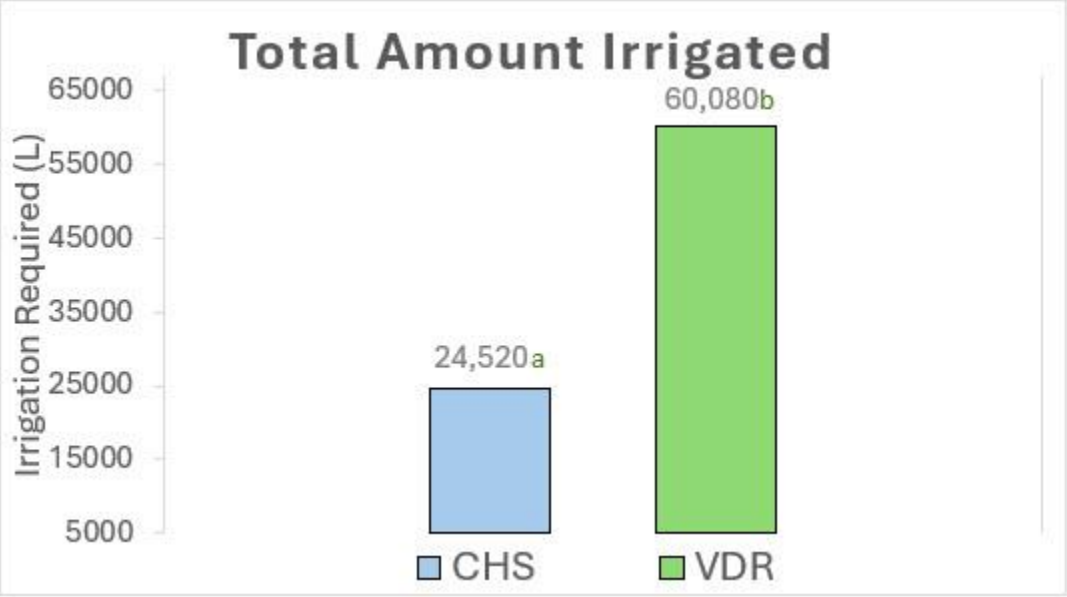

Figure 2. Irrigation applied to Variable Depth Rootzone and Capillary Hydroponic System research greens between June 21 - September 21, 2023, and 2024. Means with same letter are not significantly different (α=0.05).

Future expectations

Across the two-year trial the most significant difference between CHS and VDR is the amount of irrigation water applied. The CHS system required significantly less water than the VDR system

regardless of weather conditions. It seems logical to hypothesize that greens with identical rootzone particle size and surface contours that the green receiving more than twice as much irrigation would result in greater organic matter build up, but that was not the case. However, it could be that since we are maintaining the CHS and VDR greens at a minimal amount of irrigation, to maintain 8% VMC, that there will be no changes in organic matter content and therefore very little meaningful difference between the systems going forward other than the amount of irrigation water applied, which could change as the grass matures. The wetting and drying nature of the CHS may be creating an ideal microclimate for root diseases, since the research greens were only treated with fungicide on a preventative basis it can be hypothesized that an early fungicide program could mitigate the impact of these pathogens but more data is needed to draw concrete conclusions.

Literature Cited

Gelernter, W.D., Stowell, L.J., Johnson, M.E., Brown, C.D., & Beditz, J.F.(2015). Documenting Trends in Water Use and Conservation Practices on U.S. Golf Courses. Crop, Forage & Turfgrass Management, 1(1), cftm2015.0149. doi:https://doi.org/10.2134/cftm2015.0149

Scott, D., Rutty, M., & Peister, C. (2018). Climate variability and water use on golf courses: optimization opportunities for a warmer future. Journal of Sustainable Tourism, 26(8), 1453-1467. doi:10.1080/09669582.2018.1459629

Shaddox, T.W., Unruh, J.B., Johnson, M.E., Brown, C.D. & Stacey, G. 2022 Water use and management practices on U.S. golf courses *Crop Forage Turfgrass Manage.* 8 e20182 https://doi.org/10.1002/cft2.20182