IMPACT OF TEMPERATURE ON WATER RELEASE FROM DRiWATER TIME RELEASE WATER

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Introduction

The DRiWATER Time Release Water is a water-based gel that was developed to provide water to various plant systems where installation of a permanent irrigation system is not feasible. The gel, a mixture of vegetable gum (2%) and water (98%), is placed in contact with the soil where the gum is metabolized by soil microorganisms, resulting in the release of the water. A limited amount of information is available regarding the impact of temperature on water release from DRiWATER. This report provides the results of a laboratory study designed to provide additional quantitative data on how temperature impacts the rate of water release from DRiWATER.

Materials & Methods

The study was conducted in the laboratory at the University of Arizona Karsten Turf Research Facility (KTRF) located in Tucson, AZ. Soil containers were constructed using 30 cm (12") lengths of 10 cm (4") diameter PVC sewer pipe. Each length of pipe was capped on one end using a 10 cm (4") diameter PVC end cap which served as the bottom of the soil container. The top of each container was constructed so as to provide a port through which a DRiWATER reservoir could be inserted into the container. Tops were made by first drilling a 4.3 cm (1.625") diameter hole in the center of a 10 cm (4") diameter PVC end cap and then inserting a 12.7 cm (5") length of 3.2 cm (1.25") diameter Schedule 40 PVC pipe through the hole such that one end of the pipe was flush with the top of the endcap and the other end extended into and below the open end of the cap. The pipe was attached to the end cap using PVC adhesive. The end extending below the end cap served as the access port (casing) for the DRiWATER reservoir and was sharpened using a bench grinder to improve entry into soil. The DRiWATER reservoirs were constructed of 15.2 cm (6") lengths of 2.54 cm (1.0") diameter Schedule 40 PVC pipe. A 2.54 cm (1.0") PVC end cap was placed on one end of the pipe, but was not secured with adhesive so as to make the cap removable. Nylon window screen (1.15 mm (0.045") mesh; percent open area = 80%) was used to cover the end of the reservoir intended to contact the soil. The screen was cut into circular pieces that matched the outside diameter of the reservoir. These screen pieces were then attached to the end of the reservoir using contact cement. The window screen served to retain the DRiWATER in the reservoir while still allowing for soil contact. Each soil container was filled with the farm soil from the KTRF which is classified as sandy clay loam. Soil was removed from the upper 10 cm of the soil profile and air dried outside by placing the soil on a concrete slab for a period of two days. The air dried soil was then processed through a sieve to remove particles in excess of 2 mm in diameter and placed in a drying oven at 100$_o$C for 48 hrs. Approximately 3 kg of oven dried soil was placed in each soil container. The volume occupied by the soil was determined by measuring the height of the soil in the container and then computing the resulting volume using the diameter of the container. The soil was then wetted to a volumetric moisture level of 24% by applying the proper volume of distilled, deionized water to the surface of each container. A coffee filter was placed on the surface of the soil prior to water application to help distribute the water uniformly over the surface. Following application of water, each soil container was covered with plastic and allowed to equilibrate for a period of 48 hours. Three constant temperature thermal regimes, consisting of 15, 25, and 35degC, were established to evaluate the impact of temperature on water release from DRiWATER. The thermal regimes were established using a constant temperature cabinet. Just one cabinet was available for this study; thus, individual temperature treatments were evaluated sequentially over time (not all at the same time). Initiation dates for the temperature studies were: 19 July; 10 September; and 29 October 2003. A total of six soil containers were evaluated in each thermal regime. On the day of study initiation, lids were placed on the containers which effectively forced DRiWATER reservoir access ports into the moist soil. Soil that pushed up into access ports was removed with a small spoon and spatula. The DRiWATER reservoirs were filled by removing the endcap and forcing the open end down into a DRiWATER Gel Pack that had been opened on one end. This technique forced the DRiWATER into the reservoir. The filling process continued until DRiWATER was just beginning to ooze through the window screen on the opposite end of the reservoir. The endcap was replaced on a full reservoir and the reservoir was stored in a humidified box until insertion in the soil. Once all reservoirs were filled, they were assigned to the soil containers, and the matched containers and reservoirs were weighed on a scale with a resolution of 0.5 g. The reservoirs were then inserted through the ports until they made contact with the soil. Each reservoir was then rotated one quarter turn to ensure good contact between the reservoir and the soil. The soil containers were then placed in the constant temperature chamber and removed from the chamber only for subsequent measurements. Soil containers and their affiliated DRiWATER reservoirs were weighed every 3-7 days using a scale (0.5 g resolution). Specific measurements included: 1) gross container mass (reservoir plus container), 2) container mass without DRiWATER reservoir, and 3) mass of DRiWATER reservoir. Changes in DRiWATER reservoir mass were used to evaluate the rate at which DRiWATER was converted into water and stored as soil moisture. Data were collected on each thermal regime for a period of approximately 6 weeks.

Results and Discussion

Temperature greatly impacted the rate of water release from DRiWATER. Figure 1 shows the mean rate of water release for each temperature treatment. Water release averaged 0.218, 0.415, and 0.958 g/day at 15, 25, and 35degC, respectively; and all three rates were found to be significantly different from one another ($p<0.05$) using a standard statistical t-test (Table 1). Water release rates nearly doubled as the temperature increased from 15degC to 25degC and more than doubled between 25degC and 35degC.
Figure 2 shows the temporal pattern of DRiWATER water release for each temperature regime. The impact of temperature on water release is clearly evident in Figure 2 as is the indication that water release appears to increase with time. There appears to be a period of slow water release during the first 5-7 days after DRiWATER is placed in contact with soil. Water release then increases to a higher rate for about 15-20 days after which the release appears to accelerate again. This same pattern was observed in the previous study which examined the impact of soil moisture on water release from

DRiWATER (Brown, 2003). A hypothesis was put forth in the soil moisture study that the increasing rate of water release over time reflects an increase in microbial activity at the soil-DRiWATER interface. While microbial activity was not examined in this study, we did observe another phenomenon that may be related to the increased water release. We found that the DRiWATER remaining in the reservoirs became more liquid (less gelatinous) over time. During the latter stages of the temperature studies it was common to observe an accumulation of nearly liquefied DRiWATER in the reservoir casing (above the soil surface). The reason for this "change of state" of the DRiWATER is not clear from this study, but two possible reasons could be: 1) water from the soil is diffusing up into the DRiWATER in response to the gradient in water potential between the wet soil and DRiWATER, or 2) microbes from the soil grow up into the reservoirs and accelerate liquefaction by simply exposing more DRiWATER to microbial attack. The 3-7 mm thick black layer observed at the DRiWATER-soil interface in the soil moisture study was again observed in this study. This layer appears to be a dense, almost cemented layer consisting of organic matter and soil particles. The layer emits an odor akin to hydrogen sulfide, suggesting the layer resides in an anaerobic environment. This layer appears to have a very low permeability to water which is the reason nearly liquified DRiWATER accumulates above the DRiWATER-soil interface. The temperature study and soil moisture study (Brown, 2003) contained a similar treatment -- 24% volumetric moisture at 25degC. One should expect the two treatments to generate similar water release rates and this proved to be the case. The rate of water release from the 25degC temperature treatment was 0.415 g/day which was quite close to the 0.431 g/day obtained in the soil moisture treatment initiated at 24% volumetric content.
The water release rates in this study can be compared with values stated in the product literature. Product literature indicates water release should approach 9.5 g/carton/day. A carton produces an exposed surface area of 53.32 cm^2 which means the water release rate on a per area basis is 0.178g/cm^2/day. The exposed surface area for the DRiWATER reservoirs used in this study was 4.05 cm^2. Water release in this study, when normalized to a per unit area basis, was 0.054, 0.102, 0.236 g/cm^2/day for the 15, 25, and 35degC treatments, respectively. Clearly, the two lower temperature environments produced water release rates below product specifications. However, the water release at the 35degC treatment exceeded product specifications by about 32%. It is important to note here that the 24% soil moisture regime used in this study did not produce peak water release rates in the soil moisture study (Brown, 2003). Water release was higher when soil moisture was lower (6-18% soil moisture). It is therefore likely that water release rates would have been higher had this study employed a lower initial soil moisture regime.

Conclusions

Temperature did significantly impact the rate of water release from DRiWATER. Water release increased about two fold for each 10degC increase in soil temperature which means water release at 35degC is roughly four times that at 15degC.
The fact that water release from DRiWATER varies so much with temperature is not necessarily a negative

characteristic. In many parts of the world, evaporative demand (as indicated by reference evapotranspiration) varies by a factor of four or five over the course of the year. Evaporative demand is lowest during the coolest months when soil temperatures are low, and highest during the warmest months when soil temperatures approach peak levels for the year. The relationship between water release and temperature allows DRiWATER to “flex” to seasonal changes in evaporative demand and should be considered a desirable feature of DRiWATER. The product recommendation that the user inspect DRiWATER cartons 45-60 days after installation appears fully justified. It might be appropriate to add the clause “especially during the summer months” after the reference to 45-60 days.

References

Brown, P.W. 2003. Impact of Soil Moisture on Water Release from DRiWATER Time Release Water.
Report Submitted to DriWater, Inc. on 24 Oct. 2003.

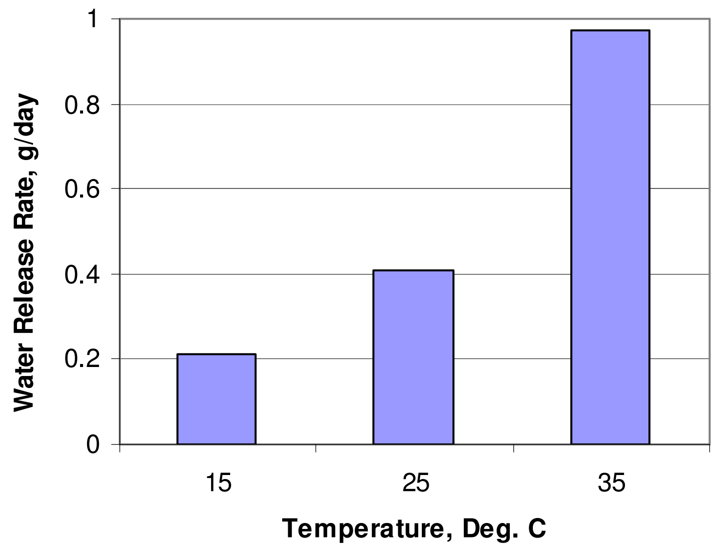

Figure 1. Rate of water release when DRiWATER was placed in contact with soil maintained at a constant temperature of 15, 25 and 35degC.

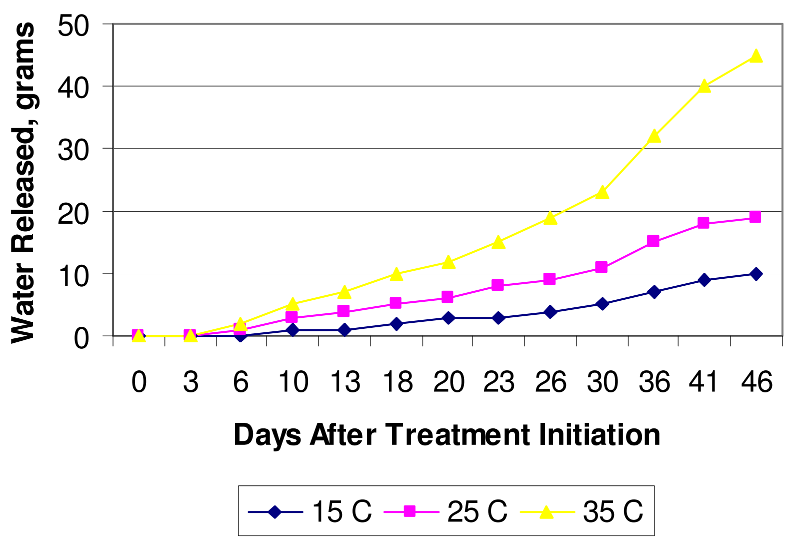

Figure 2. Cumulative release of water from DRiWATER over time for reservoirs placed in contact with soil maintained at a constant temperature of 15, 25 and 35degC.

Table 1. Statistical comparison of mean DRiWATER water release rates at 15, 25 and 35degC.

Parameter	Mean Comparison		
	15 C vs 25 C	25 C vs 35 C	15 C vs 35 C
Difference in Water Release Rate	-0.197 g/day	-0.543 g/day	-0.740 g/day
t-value	-5.37	-4.27	-6.703
P-value	0.00032*	0.0053*	0.0005*

- Means are significantly different at $p<0.05$.