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The purpose of this three-year field study conducted at the University of Maryland was to evaluate the impact of two irrigation regimes (light and frequent nighttime vs. deep and infrequent morning) and three commonly used chemicals (Daconil Ultrex, Trimit 2SC, Primer Select) and various tank-mixes of these materials on dollar spot in fairway-height creeping bentgrass. Surprisingly, dollar spot was less severe in late summer of 2002 and 2004 in plots that were irrigated daily.

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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 350 projects at a cost of \$29 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Irrigation Frequency in Late Summer Impacts Dollar Spot Severity and the Ability of Chemicals to Control the Disease

Steven J. McDonald, Peter H. Dernoeden, and Cale A. Bigelow

SUMMARY

This field study assessed the influence of two irrigation regimes (light and frequent nighttime vs. deep and infrequent morning irrigation) and six chemical treatments (Daconil Ultrex, chlorothalonil; Trimmit 2SC, paclobutrazol; Primer Select, polymeric polyoxyalkylene 95% oxoalkonyl hydroxyl polyoxylalkane diyl 5%; chlorothalonil + Trimmit 2SC, Daconil Ultrex 82.5WDG + Primer Select, and Daconil Ultrex 82.5WDG + Trimmit 2SC + Primer Select) on dollar spot severity on creeping bentgrass maintained at fairway height over a three-year period. Data indicated:

- Applying a low label rate of Trimmit 2SC alone reduced dollar spot levels in all years.
- Applying a combination of Daconil Ultrex 82.5WDG + Trimmit 2SC was beneficial in the reduction of dollar spot, but applying a tank-mix of Daconil Ultrex 82.5WDG + Primer Select was not.
- Dollar spot was more severe in late summer in creeping bentgrass that received deep and infrequent vs. light and frequent irrigation in 2002 and 2004, and disease severity was negatively correlated with volumetric soil moisture. That is, dollar spot was less severe in late summer of 2002 and 2004 in plots that were irrigated daily. This outcome was the opposite of our hypothesis, which was that frequent nighttime irrigation would enhance dollar spot severity.
- Irrigation frequency during early and mid-summer epidemics had no effect on dollar spot in any year. Soil moisture levels above 25% for this silt loam soil were associated with an improved ability of all three materials to suppress dollar spot.

Creeping bentgrass (*Agrostis stolonifera*) is one of the primary turfgrass species utilized as a fairway grass, however, dollar spot (*Sclerotinia homoeocarpa*) can be an serious disease problem

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in this species. In summer, water from irrigation is applied frequently to fairways to maintain turf health and promote vigor. The two most common approaches to irrigating fairways during summer in the mid-Atlantic region are light and frequent irrigation and deep and infrequent irrigation. Frequent irrigation (that is, five times or more per week) in summer is common primarily for aesthetic reasons. Deep and infrequent irrigation typically is recommended as a cultural disease management strategy because this practice promotes drier soil conditions, which generally would be expected to be less conducive to infection by foliar pathogens (2,7,8). Studies involving the impact of irrigation and soil moisture on dollar spot severity, however, have yielded mixed results (3,5,9).



In 2004, tarps were used to cover infrequently irrigated blocks before the onset of rain and were removed within 15 minutes after the rain had ceased.

Chemical Control of Dollar Spot

Superintendents use a variety of chemicals on creeping bentgrass fairways. Trimmit 2SC (paclobutrazol) is a growth regulator that is applied to manage excess clippings, improve turfgrass color and density, and suppress annual bluegrass populations. Trimmit 2SC also has fungistatic effects on *S. homoeocarpa* in creeping bentgrass (1). Wetting agents are used on fairways to improve water infiltration and alleviate hydrophobic soil conditions. Primer Select is a nonionic surfactant that has been shown to suppress dollar spot (4). Due to its broad spectrum of activity and low risk of resistance, chlorothalonil is perhaps the most widely used fungicide on turfgrasses. In our experiments, we used Daconil Ultrex 82.5WDG (Syngenta Crop Protection) as our source of chlorothalonil.

The purpose of this three-year field study was to evaluate the impact of two irrigation regimes (light and frequent nighttime vs. deep and infrequent morning) and three commonly used chemicals (Daconil Ultrex, Trimmit 2SC, Primer Select) and various tank-mixes of these materials on dollar spot severity in fairway-height creeping bentgrass.

Evaluating Dollar Spot Severity

This study was conducted at the University of Maryland Turfgrass Research Facility in College Park from 2002 to 2004. In autumn of each year, the site was renovated with Roundup (glyphosate, Monsanto) and reseeded with 'Crenshaw' creeping bentgrass. Eight independently irrigated blocks, 9.8 feet × 34.4 feet (3.0 meters × 10.5 meters), were outfitted with

Chemical†	Rate/1000ft ²	Infection Centers Per Plot			
		August 22		August 26	
		Frequent	Infrequent	Frequent	Infrequent
Daconil Ultrex	3.2 oz	0.0 b‡	2.0 b	0.5 b	0.0 b
Trimmit 2SC (PB)	0.18 fl oz	1.0 b	1.0 b	3.5 b	5.5 b
Primer Select (WA)	2.0 fl oz	3.3 b	46.8 a	5.8 b	62.0 a
Daconil Ultrex + PB	3.2 oz + 0.18 fl oz	0.0 b	0.0 b	0.8 b	0.3 b
Daconil Ultrex + WA	3.2 oz + 2.0 fl oz	0.0 b	0.0 b	0.0 b	0.8 b
Daconil Ultrex + PB + WA	3.2 oz + 0.18 + 2.0 fl oz	0.0 b	0.4 b	1.0 b	0.0 b
Untreated	----	18.5 a	56.8 a	29.8 a	87.3 a
Irrigation					
Frequent		3.3 b		5.9 b	
Infrequent		15.5 a		22.3 a	
ANOVA §					
Irrigation		**		**	
Chemical		***		***	
Irrigation x Chemical		***		***	
† Treatments were applied on a 14-day interval beginning June 17 and ending August 26, 2002.					
‡ Means in a column followed by the same letter are not significantly different at P < 0.05 according to Tukey's protected least significant difference test. Data were analyzed using a square root transformation, but actual means are shown.					
§ *, **, ***, and NS refer to the 0.05, 0.01, 0.001 significance levels and non-significant, respectively.					

Table 1. Number of *Sclerotinia homoeocarpa* infection centers in 'Crenshaw' creeping bentgrass fairway turf as influenced by irrigation, chlorothalonil, paclobutrazol, and a wetting agent in 2002.

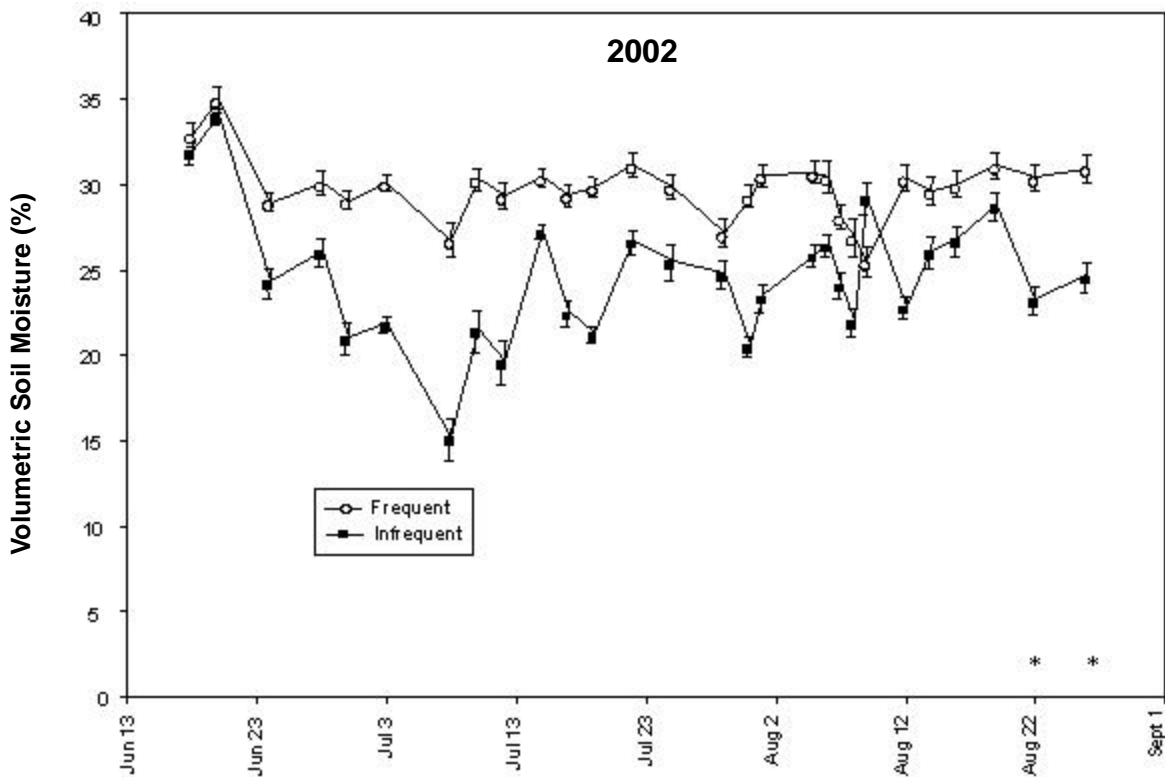


Figure 1. Soil moisture measurements (% volumetric basis) in 2002 of plots irrigated frequently versus infrequently. Vertical bars represent 1 standard error of the mean (SE). Asterisks denote that on August 22 and 26, 2002 dollar spot severity was negatively correlated with soil moisture.

pop-up irrigation heads that delivered 5.7 gallons (21.6 liters)/minute to each block. The two irrigation regimes were: infrequent morning irrigation to a soil depth of 2.5 to 3 inches (6.4 to 7.6 centimeters) and light and frequent nighttime irrigation (on average, 0.19 inch [0.5 centimeter] water applied daily during rain-free periods).

Each irrigation treatment was applied to four randomly assigned blocks. Irrigation began at 6 AM for the deep and infrequent morning treatments and at 9 PM for the light and frequent nighttime treatments. Infrequently irrigated blocks generally received water when visible drought stress symptoms were observed. Both irrigation regimes were adjusted based on prevailing weather patterns.

In 2002, a drought year, both frequently and infrequently irrigated blocks received approximately 0.9 to 1.5 inches (2.3 to 3.8 centimeters) of water weekly from irrigation or rainfall. Frequent rainfall in 2003 and 2004 prevented us from maintaining this regime. Precipitation during the study period totaled 18 inches (45.7 centime-

ters) in 2003 and 20.2 inches (51.3 centimeters) in 2004. Due to the frequent rainfall and few differences in soil moisture, the 2003 data were excluded from the results.

In 2004, tarps were used to cover infrequently irrigated blocks before the onset of rain and were removed within 15 minutes after the rain had ceased. Tarps were used on 14 occasions from June 4 to August 21, 2004. In 2004, the frequently irrigated blocks received an average of 2.5 inches (6.4 centimeters) of water per week, and the infrequently irrigated blocks received 0.8 inch (2.0 centimeters) of water per week. Volumetric soil moisture was recorded two to three times per week using time-domain reflectometry (Figure 1 and 2).

Six chemical treatments were evaluated:

1. Daconil Ultrex 82.5WDG at 3.2 ounces of product/1,000 ft²
2. Trimmit 2SC at 0.18 fluid ounce product/1,000 ft² (7.84 fluid ounces of product/acre)

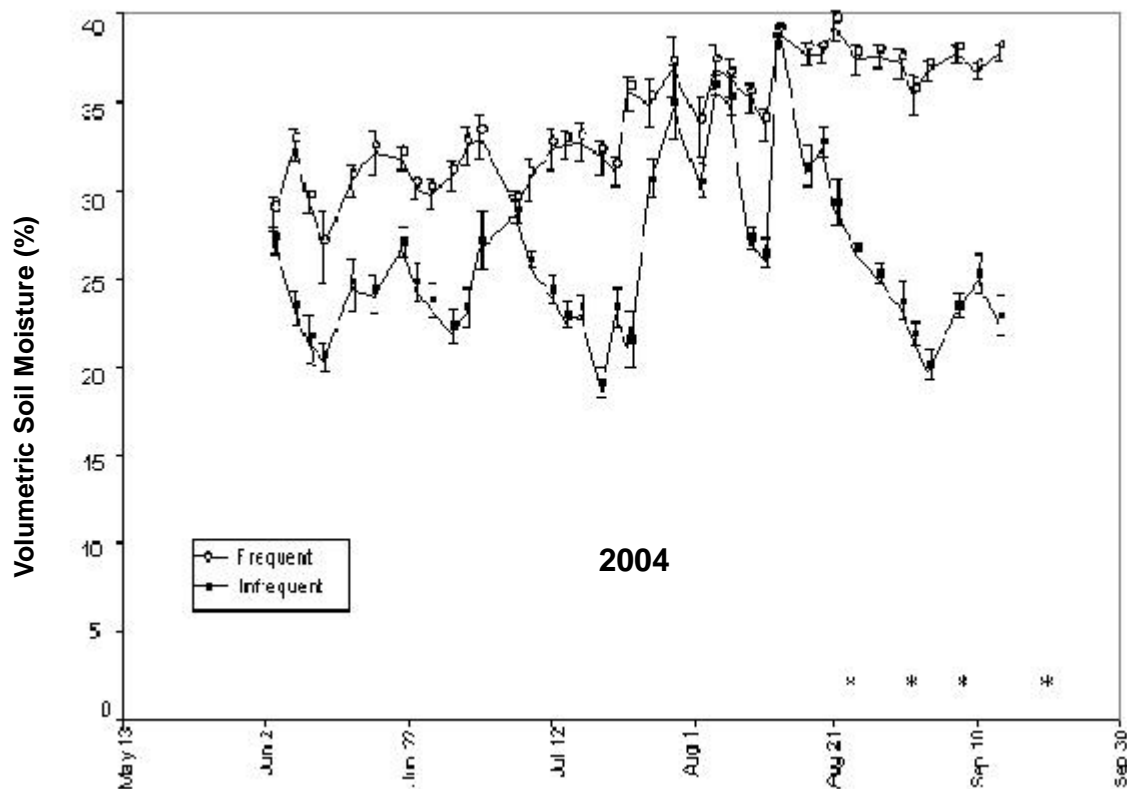


Figure 2. Soil moisture measurements (% volumetric basis) in 2004 of plots irrigated frequently versus infrequently. Vertical bars represent 1 standard error of the mean (SE). Asterisks denote that on August 24 and 29 and September 9 and 17, 2004 dollar spot severity was negatively correlated with soil moisture.

3. Primer Select at 2.0 fluid ounces of product/1,000 ft²
4. Daconil Ultrex 82.5WDG + Trimmit 2SC
5. Daconil Ultrex 82.5WDG + Primer Select
6. Daconil Ultrex 82.5WDG + Trimmit 2SC + Primer Select

Rates for the tank-mix treatments were the same as for each chemical applied alone (for 2002 treatments, Table 1). In 2004, the rate of Daconil Ultrex 82.5WDG was reduced to 1.8 ounces product/1,000 ft² (Table 2). Plots were rated 52 times for disease over the three seasons. Dollar spot was assessed by counting the number of dollar spot infection centers (ICs) per plot until they had coalesced. Generally, this was early in the study season. Thereafter, plots were rated visually on a linear 0 to 100% scale, where 100% = entire plot are blighted (PAB). Subjectively, an acceptable threshold was judged to be eight to 10 infection centers per plot, or about 0.5% of the plot area blighted.

For each plot, we calculated an area-under-disease-progress curve (AUDPC), which provides a single value that expresses disease level (that is, the higher the number, the greater the disease level) over a defined period. Area-under-disease-progress-curve values were calculated separately for early-season (that is, infection centers) data collection periods, and late-season (that is, % PAB) data collection periods (6).

Data were subjected to analysis of variance using the SAS Mixed Procedure and significantly different treatment means were separated using Tukey's protected least significant difference test. Data were analyzed using a square root transformation, but actual means are presented in tables. Full details on the research methods employed in this study can be found in McDonald et al. 2006 (6).

Results

Effect of Irrigation Regimes

Dollar Spot Severity

Dollar spot was shown to be more severe in creeping bentgrass that was irrigated infrequently in late summer 2002 and 2004. There were few significant differences among treatments in 2003 because rainfall was frequent (no data shown or discussed).

The wilting point of turf plants for this Keyport silt-loam soil was determined to be 22%. After soil moisture levels consistently fell below 23% in late summer 2002 and 2004, dollar spot became more severe in the infrequently irrigated plots.

Soil moisture averaged 15% in the infrequently irrigated plots on July 10, 2002, and dollar spot developed in those plots on July 19 (Figure 1). Dollar spot pressure increased in late August and early September 2002, when 87 infection centers were observed in the infrequently irrigated untreated plots, and 30 in the frequently irrigated untreated plots (data not shown). Soil moisture levels during this period ranged from 22% to 24% in the plots with infrequent irrigation and 29% to 32% in the plots with frequent irrigation. As soil moisture decreased, dollar spot severity increased (Table 1).

Chemical†	Rate/1000ft ²	Plot Area Blighted					
		August 30		Sept.17		PAB AUDPC	
		Frequent	Infrequent	Frequent	Infrequent	Frequent	Infrequent
	 (%).....			 (disease x time).....	
Daconil Ultrex	1.8 oz	1.0 b‡	1.5 b	9.8 abc	13.0 c	390 b	627 bc
Trimmit 2SC (PB)	0.18 fl oz	2.9 b	2.6 b	9.5 bc	15.8 c	869 b	882 b
Primer Select (WA)	2.0 fl oz	11.7 a	27.5 a	16.5 ab	46.3 b	1784 a	4326 a
Daconil Ultrex + PB	1.8 oz + 0.18 fl oz	0.5 b	0.3 b	6.5 c	4.1 d	295 b	209 c
Daconil Ultrex + WA	1.8 oz + 2.0 fl oz	0.9 b	1.5 b	12.8 abc	13.0 c	480 b	640 bc
Daconil Ultrex + PB + WA	1.8 oz + 0.18 + 2.0 fl oz	0.5 b	1.5 b	7.0 c	12.8 d	279 b	213 c
Untreated	----	11.4 a	29.3 a	18.5 a	63.3 a	1898 a	4924 a
<u>Irrigation</u>							
Frequent			4.1 b		11.5 b		857 b
Infrequent			9.2 a		24.0 a		1685 a
<u>ANOVA</u> §							
Irrigation			*		**		*
Chemical			***		***		***
Irrigation x Chemical			***		***		***

† Treatments were applied on a 14-day interval beginning June 1 and ending August 16.

‡ Means in the same column followed by the same letter are not significantly different at P <0.05 according to Tukey's protected least significant difference test. Data were analyzed using a square root transformation, but actual means are shown.

§ *, **, ***, NS and refer to significant at the 0.05, 0.01, 0.001, non-significant, respectively. The higher the PAB AUDPC number indicates that greater levels of *Sclerotinia homoeocarpa* blighting were observed.

Table 2. Percent of plot area blighted by *Sclerotinia homoeocarpa* in 'Crenshaw' creeping bentgrass as influenced by irrigation, chlorothalonil, paclobutrazol, and a wetting agent in 2004.

In 2004, a significant irrigation effect was not observed until August 24, when soil moisture averaged 23% in infrequently irrigated plots. On August 24 and 30, dollar spot severity was negatively correlated with soil moisture (Table 2). On September 9 and 17, 2004, disease severity was negatively and strongly correlated with soil moisture. Dollar spot pressure in 2004 peaked in the infrequently irrigated untreated control (63.3% plot area blighted) plots on September 17, at which time soil moisture averaged 23%. On the same day in the frequently irrigated plots, soil moisture averaged 36% and only 18.5% plot area blighted was observed in control plots. Hence, when moisture levels for this soil approached the wilting point in a range of 20% to 23% in late summer, dollar spot became more severe in the creeping bentgrass.

Low soil moisture levels in a similar range (16%-23%) occurring earlier in the season, however, were not associated with increases in dollar spot severity in any year. It is possible that when soil moisture levels were low earlier in the season, *S. homoeocarpa* inoculum levels or some other unknown factors were not sufficient to incite severe blighting.

Chemical Control

Over the three years, Daconil Ultrex alone provided acceptable dollar spot control on 15 of 16 rating dates early in the season, when infection center data were collected. In both irrigation regimes over the three years, however, late season % PAB data showed that Daconil Ultrex alone only provided an acceptable level of control on 12 of 23 rating dates. It is important to note that on nine %PAB rating dates, data were obtained 14 or more days after Daconil Ultrex was last applied. Hence, Daconil Ultrex, even at the reduced rate evaluated in 2004, generally provided acceptable dollar spot control, but only in frequently irrigated turf late in the season, where disease pressure was less versus the infrequently irrigated plots.

The data for the area-under-disease-progress curve (AUDPC) showed that Trimmit 2SC alone reduced dollar spot levels in all years.

On six occasions over the three years when the dollar spot threshold of eight to 10 infection centers per plot had been exceeded in untreated plots, Trimmit 2SC alone provided acceptable dollar spot control (Tables 1, 2; most data not shown).

Trimmit 2SC alone provided better dollar spot control in the frequently irrigated plots on 9 of 13 rating dates, when compared to the infrequently irrigated plots in 2002 and 2004. Over all years, Trimmit 2SC alone reduced dollar spot blighting by 40% to 60% on 11 rating dates and by greater than 60% on 20 rating dates. It should be noted that the Trimmit 2SC rate we evaluated (0.18 ounce product/1,000 square feet) was a low label rate. These results support earlier work (1), corroborating that Trimmit 2SC applied alone provides a significant level of dollar spot suppression when applied to fairway height creeping bentgrass.

On seven of 52 rating dates over three years, Primer Select reduced dollar spot by as much as 30% to 50% (most data not shown). When examining all area-under-disease progress-curve data, however, Primer Select alone reduced dollar spot levels only twice, when compared to the untreated control. Applying a combination of Daconil Ultrex 82.5WDG + Trimmit 2SC was beneficial on a majority of the rating dates, but applying a tank-mix of Daconil Ultrex 82.5WDG + Primer Select was not.

Discussion

Data from this study indicates that maintaining moisture levels above 25% (that is, slightly above the wilting point) for this soil in late summer when disease pressure is severe reduces dollar spot and improves the ability of Daconil Ultrex, Trimmit 2SC, and Primer Select to suppress the disease in fairway-height creeping bentgrass. Both Trimmit 2SC and Primer Select are not fungicides. However, each material did provide a reduction in dollar spot severity on various dates over the three-year study period. Also, because the rate and application intervals for Daconil Ultrex are restricted, these data will help

superintendents use chlorothalonil products to more efficiently manage dollar spot.

It should be pointed out that deep and infrequent irrigation is a sound agronomic practice for creeping bentgrass grown on golf courses. The findings of this study, however, indicate that golf course superintendents should keep soils underlying creeping bentgrass fairway moist enough to avoid wilt symptoms and especially extended periods of drought stress in late summer where dollar spot is chronically severe. Excessive irrigation, however, has many potential negative effects and should be avoided.

The mechanism by which low soil moisture conditions in mid-to-late summer predisposed creeping bentgrass to more severe damage from *S. homoeocarpa* is unknown, but some theories are discussed. It is possible that *S. homoeocarpa* is more competitive under conditions of low soil moisture, or that drought and other environmental or mechanical stresses weaken plants, rendering them more susceptible to the pathogen during late summer. Furthermore, turf managed under low soil moisture levels or drought stress grows more slowly and is less likely to recover rapidly from *S. homoeocarpa* damage.

It also is possible in soils with high moisture levels that there is an increase in microbial populations, which antagonize, compete with, or, in some way, reduce the capacity of *S. homoeocarpa* to infect plants. Finally, more N may be available to plants due to an increase in mineralization in warm and wet soils. The availability of more N can stimulate recovery from blighting caused by *S. homoeocarpa*. Because environmental and soil conditions vary widely among regions, these findings and conclusions may apply only to creeping bentgrass grown in a transition zone climate in the mid-Atlantic region.

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