

Water Savings and Return on Investment of a New Drought Resistant Turfgrass¹

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Abstract

Bermudagrass is a commonly used turfgrass for home lawns and sports fields. Given increasing pressure to conserve water throughout the U.S., there is a desire by many homeowners to incorporate more drought-tolerant turfgrasses into their landscape. ‘TifTuf’ is a new cultivar of bermudagrass that has increased drought tolerance compared to similar cultivars. ‘TifTuf’ is currently sold at a premium price compared to other bermudagrass cultivars. However, there is currently no information regarding the payback period and potential water savings for ‘TifTuf’. In this study, we developed a model to evaluate potential cost savings for ‘TifTuf’ relative to a conventional bermudagrass. We found cost and water savings are highly dependent on geographic location and water rates. Within the Southeast, the average water savings per year is 12.88 cm with water cost savings around \$799 per 0.41 ha. Payback period for a new lawn in the Southeast (recoup only the \$0.05 per 0.09 m² premium) is around 3–4 years, while a payback period for a replacement lawn (recoup the full cost of the lawn, \$0.36 per 0.09 m²) is around 21 years. In the Southwest, the water savings and cost savings are higher, implying a shorter payback period.

Index words: bermudagrass, ‘TifTuf’, drought tolerance.

Species used in this study: *Cynodon dactylon* x *C. transvaalensis*: DT-1 ‘TifTuf’.

Significance to the Horticulture Industry

As questions around water usage in agriculture continue to gain traction throughout the U.S., it is critical to examine how new turfgrass cultivars can impact water use. ‘TifTuf’ is a relatively new cultivar of bermudagrass that has increased drought tolerance compared to similar cultivars. Given increasing pressure to conserve water throughout the U.S., there is a desire by many consumers to incorporate more drought tolerant turfgrasses into their landscape. Since ‘TifTuf’ has been proven to provide increased drought tolerance, it is currently sold at a premium price compared to other bermudagrass cultivars. We found that thousands of liters (L) of water can be saved by utilizing ‘TifTuf’ even when ‘TifTuf’ does not achieve the drought tolerance (38% less water need) found by Schwartz (2017). Further, we found the payback period to be under four years for most all cities in the study when only having to recoup the five cent per 0.09 m² (one square foot) premium for ‘TifTuf’.

Introduction

Conservation of water has become an increasingly important issue throughout the United States. Drought frequency and the disappearance of reservoirs around the country have led to a change in water usage for many Americans. Awareness of water issues has led to the creation of a market for less water-intense products.

According to Yue et al. (2012), consumers are becoming increasingly environmentally conscious and are making more ecologically minded purchases. Curtis and Cowee (2010) found that 37.1% of people feel they are very responsible for conserving water and 49% believe they are fairly responsible.

With respect to turfgrass, Curtis and Cowee (2010) showed that more than half of their respondents (52.6%) valued drought tolerance out of all turfgrass attributes tested. Drought tolerance is an attractive attribute for two main reasons. Homeowners like to save money on their monthly water bills, but also like to feel as if they are being environmentally conscious by saving water.

Hugie, Yue, and Watkins (2012) found that the most important characteristic of turfgrass to consumers is shade tolerance and the consumers who put a high value on shade tolerance also put a high emphasis on water-conscious crops. Further, they found that consumers were willing to pay \$9.70 more per 92.90 square meters (m²) (1,000 square feet) for water-conscious crops. Across a five-state sample of southeastern and mid-southern states, Ghimire et al. (2016) showed that consumers’ highest priority is low maintenance cost, followed by shade tolerance and drought tolerance. The lowest priority for the five states was a low purchase price (Ghimire et al. 2016). Ghimire et al. (2016) state that “price is a small factor for overall replacement of lawn or sod installation”.

Bermudagrass cultivars are some of the most drought-tolerant turfgrasses (Harivandi et al. 2009) with the ‘TifTuf’ bermudagrass cultivar having better drought tolerance than previous cultivars developed (Schwartz 2017, Schwartz et al. 2018). Along with increased drought tolerance, ‘TifTuf’ has a shorter dormancy period, higher traffic tolerance, and has shown some shade tolerance (Schwartz 2017, Schwartz et al. 2018). Furthermore, ‘TifTuf’ has been shown to survive for 28 days without rainfall or precipitation with acceptable turf quality levels at 21 and 28 days (Jespersen et al. 2019).

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The most prevalent substitute to ‘TifTuf’ in the Southeastern United States are older bermudagrass cultivars, like ‘Tifway 419’. For this paper, the term conventional bermudagrass is used to describe previous cultivars that do not have the same drought tolerance as ‘TifTuf’. However, ‘TifTuf’ costs a premium of five cents per 0.09 m² (one square foot) of sod more than the conventional bermudagrass cultivars. While the initial cost of ‘TifTuf’ is higher, the payback period from decreased water usage and the potential cost savings is unknown. Though some consumers may not care about costs or payback period, some consumers value return on investment as part of their decision-making process. In calculating cost savings, water savings, and payback period, amount of rainfall and the water rates of the city where the homeowner live are critical factors in the costs and payback period. Areas with lower rainfall or higher water rates have the potential to benefit more from a drought-tolerant turfgrass as compared to an area with high rainfall or lower water rates. We calculated and compared cost savings, water savings, and payback period for homeowners installing ‘TifTuf’ relative to conventional bermudagrass in order to assess whether it is economically and environmentally viable to install ‘TifTuf’.

Materials and Methods

To determine water and cost implications of using ‘TifTuf’, we utilized past weather data and city water costs to simulate the potential financial returns for ‘TifTuf’ in five major cities in the Southeastern United States: Atlanta (Georgia), Athens (Georgia), Columbus (Georgia), Macon (Georgia), and Birmingham (Alabama). We also examined the potential for market expansion of ‘TifTuf’ into six cities in the Southwest and West: Dallas/Fort Worth (Texas), Phoenix (Arizona), Reno (Nevada), Las Vegas (Nevada), San Diego (California), and Bakersfield (California). These locations were chosen based on population size, varying rainfall, potential for adoption of warm-season grasses, and availability of daily precipitation data. Population size is important given a major component of marketing turfgrass is done through word of mouth. Hurd (2006) found that landscapes of others (i.e., regional culture) play an important role in the decisions of consumers. Hurd’s findings reveal the importance of marketing to areas with high populations, especially in areas like subdivisions.

To determine the cost of irrigation, we used equation one:

$$CI_{ij} = CWR_j * WA_{ij} \quad (1)$$

where CI is the cost of irrigation for the *i*th homeowner in the *j*th city, CWR_{*j*} is the water rate in the *j*th city, and WA is the amount of water used irrigating the lawn. WA is calculated as:

$$WA_{ij} = [Need_{ijm} * (1 - Tif)] - Rainfall_{ijm} \quad (2)$$

where Need is the optimal amount of water needed per 0.41 hectare (ha) (one acre) by the *i*th homeowner in the *j*th city during the *m*th week, Rainfall is the amount of rainfall, and Tif is the drought tolerance level of ‘TifTuf’. On average,

‘TifTuf’ has been found to be 38% more drought-tolerant than conventional bermudagrass, i.e. it only needs 62% of the water required by a conventional bermudagrass (Schwartz 2017). For our simulations, we specified 2.54 centimeter (cm) (one inch) of water per 0.41 ha (one acre) per week as the optimal amount of water needed, which equates to 102,789 L (27,154 gallons) of water. 2.54 cm (one inch) of water per 0.41 ha (one acre) per week was specified as the optimal amount as it is a commonly recommended level of irrigation (McCarty 2011, University of Georgia Cooperative Extension 2007). When Tif equals zero the ‘TifTuf’ cost is equivalent to the conventional bermudagrass cost. However, as Tif increases, the amount of water needed decreases and the cost difference between ‘TifTuf’ and a conventional bermudagrass is a function of water rate and ‘TifTuf’’s drought tolerance, i.e., Tif.

Of note, this paper focuses on the costs associated with using city water and not well water; homeowners using well water would experience lower cost savings (due to lower water rates) and longer payback periods as the cost savings are most likely lower for these homeowners. However, any water savings would be the same for homeowners using city and well water for irrigation. With respect to the number of well water users, around 10% of housing units in the U.S. utilize an individual well (United States Census Bureau 2019a, United States Census Bureau 2019b).

Residential water rates were retrieved from the University of North Carolina Environmental Finance Center (2017) for cities in Alabama, Arizona, Georgia, and Texas. Water rates for cities in Nevada (Reno and Las Vegas) and California (Bakersfield and San Diego) were retrieved from their respective city websites. Water rates vary between \$0.0019/3.79 L in Phoenix, Arizona to \$0.0144 in San Diego, California (Table 1).

Daily rainfall data was retrieved from the National Weather Service Forecast (NOWData, 2017). The NOWData provides daily precipitation amounts for different areas throughout the country. We utilized six years of daily rainfall data from January 1, 2011 to December 31, 2016. NOWData reports rainfall in amounts that are less than a 0.03 of a cm (hundredth of an inch) as “T” (“NOWData,” 2017). We replaced all “T” values with 0, because we assumed that less than a 0.03 cm (hundredth of an inch) of rain would not make a significant difference in irrigation amounts and irrigation costs. We used the Atlanta area, Athens area, Columbus metropolitan, Macon middle GA, Birmingham, Dallas/Fort Worth area, Las Vegas, Reno, Bakersfield, San Diego, and Phoenix for the locations of the NOWData.

We calculated the sum of weekly rainfall for all six years of our data (Table 1). Further, we calculated the in-season (May-September) rainfall levels. The in-season levels represent the time when a majority of irrigation takes place for bermudagrass. Therefore, we focus the rest of the paper and analysis on the in-season timeframe. Notably for the cities in our study, around 40-50% of the rainfall occurs during the in-season time period with the exception of

Table 1. Rainfall and water rates for cities utilized in the study based on 2017 data for water rates and a six year average (2011-2016) for rainfall.

City	Time	6-yr total (in cm)	Average per year (in cm)	% within season	Water rates (\$/3.79 L) ²
Athens, GA	All year	717.372	119.563	—	\$0.006802
	In-season	310.337	—	43%	
Atlanta, GA	All year	754.304	125.717	—	\$0.006908
	In-season	314.884	—	42%	
Columbus, GA	All year	731.291	121.882	—	\$0.003230
	In-season	281.991	—	39%	
Macon, GA	All year	687.349	114.559	—	\$0.004700
	In-season	282.092	—	41%	
Birmingham, AL	All year	829.437	138.240	—	\$0.007806
	In-season	344.018	—	41%	
Dallas, TX	All year	523.113	87.186	—	\$0.004988
	In-season	231.165	—	44%	
Phoenix, AZ	All year	99.238	16.540	—	\$0.001900
	In-season	54.153	—	55%	
Las Vegas, NV	All year	55.067	9.177	—	\$0.005590
	In-season	26.975	—	49%	
Reno, NV	All year	94.640	15.773	—	\$0.003400
	In-season	28.372	—	30%	
Bakersfield, CA	All year	69.520	11.587	—	\$0.010400
	In-season	4.826	—	7%	
San Diego, CA	All year	124.917	20.828	—	\$0.014400
	In-season	18.440	—	15%	

²Data taken from the University of North Carolina Environmental Finance Center (2017), city webpages, and the National Weather Service. In-season refers to May–September.

Bakersfield where only 7% of rainfall fell during our defined irrigation season.

With respect to irrigation, 51% of homeowners' report having an irrigation system with 17% reporting they irrigate nine months or more (Bowen 2013). Furthermore, 79% of homeowners reported they did not track how much water they used while irrigating their lawn (Bowen 2013). As such, we utilize simulations to test how varying 'TifTuf's drought tolerance and homeowner irrigation amounts impact cost and water savings.

Simulations assuming changing assumptions. Assuming respondents will achieve peak drought tolerance from 'TifTuf' (38% less water required than conventional bermudagrass) or irrigate optimally (watering up to 2.54 cm per 0.41 ha per week) would most likely lead to errant conclusions. Therefore, we simulated varying irrigation levels (0%, 25%, 50%, 75%, 100%, 125%) as a percentage of needed irrigation amounts as well as varying 'TifTuf' drought tolerance levels (0%, 9.5%, 19%, 28.5%, 38%, 47.5%). These drought tolerance levels represent 0%, 25%, 50%, 75%, 100%, and 125% of the published 38% level.

We simulated the potential cost and water savings of 'TifTuf' and the payback period in two different scenarios. In the first scenario, a homeowner is replacing their current lawn with 'TifTuf'. In the second scenario the homeowner is installing a new lawn and choosing 'TifTuf' over conventional bermudagrass. When replacing the lawn with 'TifTuf', the owner pays the full 36 cents per 0.09 m² (one square foot) price since they could leave their current lawn intact, but with a new lawn the homeowner will only pay the five cent premium that is placed on 'TifTuf' given they are assumed to be purchasing some type of bermudagrass.

For the first scenario, we multiplied \$0.36 per 0.09 m² (one square foot) times 4,047 m² (43,560 square feet). This

allows us to get the cost of installation per 0.09 m² (one square foot) for the replacement of a lawn with 'TifTuf'. The calculation for a new lawn is the same, but we assumed that the homeowner is installing a new lawn, so the premium of \$0.05 per 0.09 m² (one square foot) is the only charge that needs to be considered. The replacement lawn cost is \$15,681 per 0.41 ha (one acre), while the new lawn cost is \$2,178 per 0.41 ha (one acre). To calculate the payback period for each scenario, we divided the total installation cost by the yearly savings, calculated as average savings per year:

$$\text{Payback period (replaced lawn)} = \frac{3.88 \text{ m}^2 * 4,047 \text{ m}^2}{\text{Average Savings per year}} \quad (3)$$

$$\text{Payback period (new lawn)} = \frac{0.54 \text{ m}^2 * 4,047 \text{ m}^2}{\text{Average Savings per year}} \quad (4)$$

Results and Discussion

Optimal scenario: 38% drought tolerance and 2.54 cm (1inch) water per 0.41 ha (one acre). Within Georgia (the primary location where 'TifTuf' is currently sold), water savings was around 514,816 L (136,000 gallons) per year per homeowner in irrigation of a 0.41 ha (one-acre) lawn (Table 2). The mean annual costs savings ranged from \$486 in Columbus to \$969 in Athens. The rainfall amounts were similar for these cities, so the water rates were the main driver of savings. On the environmental side, each homeowner would need to water around 12.7 cm (five inches) less per season with 'TifTuf' compared to conventional bermudagrass to achieve the optimal water

Table 2. TifTuf water and cost savings in-season as calculated at varying drought tolerance levels compared to older bermudagrass cultivars.²

City	Water/Cost Savings and Payback Period	Varying TifTuf drought tolerance					
		0%	9.5%	19.0%	28.5%	38.0%	47.5%
Athens, GA	TifTuf annual water savings (cm)	0.00	2.67	5.33	8.00	10.67	13.31
	TifTuf annual cost savings	\$0.00	\$193.74	\$387.49	\$581.23	\$774.98	\$968.72
	Payback period replacement in years	—	80.94	40.47	26.98	20.23	16.19
	Payback period new in years	—	11.24	5.62	3.75	2.81	2.25
Atlanta, GA	TifTuf annual water savings (cm)	0.00	2.31	4.60	6.91	9.19	11.51
	TifTuf annual cost savings	\$0.00	\$169.97	\$339.95	\$509.92	\$679.90	\$849.87
	Payback period replacement in years	—	92.26	46.13	30.75	23.06	18.45
	Payback period new in years	—	12.81	6.41	4.27	3.20	2.56
Columbus, GA	TifTuf annual water savings (cm)	0.00	2.82	5.61	8.43	11.25	14.07
	TifTuf annual cost savings	\$0.00	\$97.11	\$194.22	\$291.34	\$388.45	\$485.56
	Payback period replacement in years	—	161.48	80.74	53.83	40.37	32.30
	Payback period new in years	—	22.43	11.21	7.48	5.61	4.49
Macon, GA	TifTuf annual water savings (cm)	0.00	2.67	5.31	7.98	10.64	13.28
	TifTuf annual cost savings	\$0.00	\$133.57	\$267.14	\$400.71	\$534.28	\$667.84
	Payback period replacement in years	—	117.40	58.70	39.13	29.35	23.48
	Payback period new in years	—	16.31	8.15	5.44	4.08	3.26
Birmingham, AL	TifTuf annual water savings (cm)	0.00	2.44	4.90	7.34	9.80	12.24
	TifTuf annual cost savings	\$0.00	\$204.52	\$409.04	\$613.56	\$818.08	\$1,022.60
	Payback period replacement in years	—	76.67	38.34	25.56	19.17	15.33
	Payback period new in years	—	10.65	5.32	3.55	2.66	2.13
Dallas, TX	TifTuf annual water savings (cm)	0.00	3.35	6.73	10.08	13.44	16.81
	TifTuf annual cost savings	\$0.00	\$179.26	\$358.52	\$537.78	\$717.05	\$896.31
	Payback period replacement in years	—	87.48	43.74	29.16	21.87	17.50
	Payback period new in years	—	12.15	6.07	4.05	3.04	2.43
Phoenix, AZ	TifTuf annual water savings (cm)	0.00	4.78	9.55	14.30	19.08	23.85
	TifTuf annual cost savings	\$0.00	\$96.87	\$193.73	\$290.60	\$387.46	\$484.33
	Payback period replacement in years	—	161.89	80.94	53.96	40.47	32.38
	Payback period new in years	—	22.48	11.24	7.49	5.62	4.50
Las Vegas, NV	TifTuf annual water savings (cm)	0.00	5.08	10.19	15.27	20.37	25.45
	TifTuf annual cost savings	\$0.00	\$304.24	\$608.48	\$912.72	\$1,216.96	\$1,521.20
	Payback period replacement in years	—	51.54	25.77	17.18	12.89	10.31
	Payback period new in years	—	7.16	3.58	2.39	1.79	1.43
Reno, NV	TifTuf annual water savings (cm)	0.00	5.03	10.06	15.11	20.14	25.17
	TifTuf annual cost savings	\$0.00	\$183.00	\$366.00	\$549.00	\$732.01	\$915.01
	Payback period replacement in years	—	85.69	42.85	28.56	21.42	17.14
	Payback period new in years	—	11.90	5.95	3.97	2.98	2.38
Bakersfield, CA	TifTuf annual water savings (cm)	0.00	5.38	10.80	16.18	21.56	26.97
	TifTuf annual cost savings	\$0.00	\$599.61	\$1,199.22	\$1,798.83	\$2,398.44	\$2,998.05
	Payback period replacement in years	—	26.15	13.08	8.72	6.54	5.23
	Payback period new in years	—	3.63	1.82	1.21	0.91	0.73
San Diego, CA	TifTuf annual water savings (cm)	0.00	5.26	10.49	15.75	21.01	26.24
	TifTuf annual cost savings	\$0.00	\$808.06	\$1,616.13	\$2,424.19	\$3,232.26	\$4,040.32
	Payback period replacement in years	—	19.41	9.70	6.47	4.85	3.88
	Payback period new in years	—	2.70	1.35	0.90	0.67	0.54

²In-season refers to May-September

rate of 2.54 cm (one-inch) per 0.41 ha (one acre). On average, it would take a homeowner 3-5 years to obtain enough water savings for a new lawn (recouping \$0.05 per 0.09 m² (one square foot) 'TifTuf' premium) and 16-32 years for payback on a replacement lawn [recouping \$0.36 per 0.09 m² (one square foot) cost]. Whether a 3-5 or 16-32 year payback period is acceptable to a homeowner is outside the scope of this paper as this would be an individual homeowner decision. We only provide the potential cost savings, water savings, and payback periods as a guide to what a homeowner might expect.

Outside of the state of Georgia, the results differed due to less rainfall and varying costs of water. As expected, cost savings by location were indicative of the water rates for the city and the rainfall amount. The average annual cost savings were highest for San Diego (\$4,040) and Bakersfield (\$2,998). Bakersfield had the highest irrigation

need to reach 2.54 cm (one-inch) of water per 0.41 ha (one acre) per week and San Diego had the highest water rate (Table 1). Furthermore, Bakersfield had the second highest water rate and San Diego had the second highest irrigation need. Combining these two factors increases the costs savings for these cities as lower rainfall implies the homeowner would need to irrigate more while the higher water rate would mean the homeowner pays more compared to homeowners in other cities for their increased irrigation. Payback for San Diego and Bakersfield occurred within a year for these cities for new lawns ('TifTuf' premium recovery) and within 4-6 years for lawn replacement. With respect to water savings, an average homeowner in Bakersfield would save 26.97 cm (10.61 inches) of water per 0.41 ha (one acre) per season.

Reno, Las Vegas, and Phoenix have similar rainfall levels as San Diego and Bakersfield, yet the cost savings is

Table 3. TifTuf water and cost savings in-season as calculated at various irrigation levels.²

City	Water/Cost Savings and Payback Period	Varying irrigation levels [% of need to reach 2.54 cm (1 inch) per week]					
		0%	25%	50%	75%	100%	125%
Athens, GA	TifTuf annual water savings (cm)	0.00	2.64	5.28	7.92	10.57	13.21
	TifTuf annual cost savings	\$0.00	\$192.14	\$384.27	\$576.41	\$768.54	\$960.68
	Payback period replacement in years	—	81.62	40.81	27.21	27.21	16.32
	Payback period new in years	—	11.34	5.67	3.78	2.83	2.27
Atlanta, GA	TifTuf annual water savings (cm)	0.00	2.31	4.65	6.96	9.27	11.61
	TifTuf annual cost savings	\$0.00	\$171.40	\$342.80	\$514.20	\$685.60	\$857.00
	Payback period replacement in years	—	91.49	45.75	30.50	30.50	18.30
	Payback period new in years	—	12.71	6.35	4.24	3.18	2.54
Columbus, GA	TifTuf annual water savings (cm)	0.00	2.79	5.61	8.41	11.23	14.02
	TifTuf annual cost savings	\$0.00	\$96.85	\$193.70	\$290.54	\$387.39	\$484.24
	Payback period replacement in years	—	161.92	80.96	53.97	53.97	32.38
	Payback period new in years	—	22.49	11.24	7.50	5.62	4.50
Macon, GA	TifTuf annual water savings (cm)	0.00	2.64	5.31	7.95	10.59	13.23
	TifTuf annual cost savings	\$0.00	\$133.06	\$266.13	\$399.19	\$532.26	\$665.32
	Payback period replacement in years	—	117.85	58.93	39.28	39.28	23.57
	Payback period new in years	—	16.37	8.18	5.46	4.09	3.27
Birmingham, AL	TifTuf annual water savings (cm)	0.00	2.44	4.88	7.34	9.78	12.22
	TifTuf annual cost savings	\$0.00	\$203.98	\$407.97	\$611.95	\$815.93	\$1,019.92
	Payback period replacement in years	—	76.88	38.44	25.63	25.63	15.38
	Payback period new in years	—	10.68	5.34	3.56	2.67	2.14
Dallas, TX	TifTuf annual water savings (cm)	0.00	3.33	6.65	9.98	13.31	16.64
	TifTuf annual cost savings	\$0.00	\$177.55	\$355.09	\$532.64	\$710.18	\$887.73
	Payback period replacement in years	—	88.32	44.16	29.44	29.44	17.66
	Payback period new in years	—	12.27	6.13	4.09	3.07	2.45
Phoenix, AZ	TifTuf annual water savings (cm)	0.00	4.78	9.55	14.30	19.08	23.85
	TifTuf annual cost savings	\$0.00	\$96.87	\$193.73	\$290.60	\$387.46	\$484.33
	Payback period replacement in years	—	161.89	80.94	53.96	53.96	32.38
	Payback period new in years	—	22.48	11.24	7.49	5.62	4.50
Las Vegas, NV	TifTuf annual water savings (cm)	0.00	5.08	10.16	15.24	20.32	25.40
	TifTuf annual cost savings	\$0.00	\$303.52	\$607.04	\$910.56	\$1,214.08	\$1,517.60
	Payback period replacement in years	—	51.67	25.83	17.22	17.22	10.33
	Payback period new in years	—	7.18	3.59	2.39	1.79	1.44
Reno, NV	TifTuf annual water savings (cm)	0.00	5.03	10.06	15.09	20.12	25.15
	TifTuf annual cost savings	\$0.00	\$182.74	\$365.48	\$548.22	\$730.95	\$913.69
	Payback period replacement in years	—	85.81	42.91	28.60	28.60	17.16
	Payback period new in years	—	11.92	5.96	3.97	2.98	2.38
Bakersfield, CA	TifTuf annual water savings (cm)	0.00	5.38	10.77	16.15	21.54	26.92
	TifTuf annual cost savings	\$0.00	\$598.67	\$1,197.34	\$1,796.01	\$2,394.68	\$2,993.35
	Payback period replacement in years	—	26.19	13.10	8.73	8.73	5.24
	Payback period new in years	—	3.64	1.82	1.21	0.91	0.73
San Diego, CA	TifTuf annual water savings (cm)	0.00	5.26	10.49	15.75	21.01	26.24
	TifTuf annual cost savings	\$0.00	\$808.06	\$1,616.13	\$2,424.19	\$3,232.26	\$4,040.32
	Payback period replacement in years	—	19.41	9.70	6.47	6.47	3.88
	Payback period new in years	—	2.70	1.35	0.90	0.67	0.54

²In-season refers to May –September

considerably lower in the non-California cities. This is due to both lower water rates and an increased amount of rainfall in-season (Table 1 and 2). Dallas had similar annual savings as Reno (\$896 in Dallas per year vs. \$915 in Reno per year) though Dallas had significant more rainfall than Reno, but had a higher water rate. Water savings for Reno was around 25.17 cm (ten inches) of water per 0.41 ha (one acre) per year.

Cost savings at varying drought tolerance levels. Not all homeowners will obtain the 38% drought tolerance for a myriad of reasons. Therefore, we simulated the potential impacts of decreased and increased drought tolerance levels (Table 2). Obviously, if a homeowner receives 0% drought tolerance compared to the conventional bermudagrass then there is no cost savings or water savings. Higher drought tolerance significantly increases water savings, thus decreas-

ing the payback period. For instance, in Athens obtaining 9.5% drought tolerance takes 11 and 81 years to recoup the investment costs for a new and replacement lawn, respectively. A 19% drought tolerance would drop the payback period to 6 years and 41 years for new and replacement lawns, respectively. For this reason, landscapers and ‘TifTuf’ suppliers need to ensure that they follow recommendations when installing ‘TifTuf’ and should educate consumers on the best ways to maximize drought tolerance.

Costs savings at varying irrigation levels. Drought tolerance of ‘TifTuf’ is likely to be more consistent than irrigation as many homeowners are more likely variable in their irrigation regimes. We simulated the impact on cost savings, water savings, and payback period given varying irrigation regimes (Table 3). When a homeowner does not irrigate, there are no water or cost savings (between

Table 4. Rainfall statistics for the eleven cities utilized in the study for 2011-2016.

City	Time	% timeframe with less than 2.54 cm (1 inch) of rainfall or less per week					Average rainfall (in cm) over various timeframes				
		7 days	14 days	21 days	28 days	35 days	7 days	14 days	21 days	28 days	35 days
Athens, GA	All year	68%	38%	21%	11%	5%	2.291	4.575	6.848	9.121	11.387
	In-season ^z	71%	39%	18%	10%	6%	2.281	4.516	6.678	8.722	10.739
Atlanta, GA	All year	63%	35%	16%	8%	4%	2.408	4.808	7.203	9.596	11.984
	In-season	61%	33%	16%	9%	7%	2.316	4.511	6.596	8.608	10.533
Columbus, GA	All year	71%	42%	24%	13%	10%	2.334	4.658	6.975	9.289	11.600
	In-season	68%	43%	26%	15%	11%	2.073	4.074	6.015	7.816	9.586
Macon, GA	All year	69%	40%	21%	10%	5%	2.195	4.384	6.566	8.743	10.917
	In-season	68%	38%	20%	12%	9%	2.075	4.067	6.015	7.849	9.642
Birmingham, AL	All year	58%	27%	15%	10%	7%	2.649	5.281	7.904	10.528	13.150
	In-season	61%	31%	21%	15%	13%	2.530	4.915	7.206	9.406	11.560
Dallas, TX	All year	76%	55%	38%	25%	16%	1.671	3.343	5.004	6.662	8.321
	In-season	76%	58%	46%	37%	29%	1.699	3.320	4.846	6.228	7.457
Phoenix, AZ	All year	98%	94%	88%	82%	76%	0.318	0.635	0.950	1.267	1.585
	In-season	97%	90%	81%	73%	66%	0.399	0.792	1.184	1.554	1.925
Las Vegas, NV	All year	99%	97%	95%	94%	93%	0.175	0.351	0.528	0.704	0.879
	In-season	99%	97%	96%	95%	94%	0.198	0.373	0.549	0.724	0.894
Reno, NV	All year	97%	93%	88%	81%	73%	0.302	0.605	0.907	1.207	1.509
	In-season	97%	95%	93%	88%	83%	0.208	0.396	0.569	0.732	0.869
Bakersfield, CA	All year	99%	96%	93%	89%	86%	0.218	0.434	0.653	0.869	1.087
	In-season	100%	100%	100%	100%	100%	0.036	0.058	0.076	0.089	0.097
San Diego, CA	All year	94%	88%	83%	77%	69%	0.394	0.785	1.176	1.567	1.958
	In-season	98%	96%	93%	92%	90%	0.135	0.259	0.368	0.439	0.511

^zIn-season refers to May –September

conventional and ‘TifTuf’ bermudagrass) as the homeowner is solely relying on rainfall for irrigation. Though many homeowners elect to not irrigate their lawns, ‘TifTuf’ may still enhance the probability a lawn survives a prolonged drought without irrigation. ‘TifTuf’ can survive periodic drought (e.g., up to 28 days) without water (Jespersen et al. 2019). In comparison, other bermudagrass cultivars have been shown to be less green after seven days of drought compared to ‘TifTuf’ (Schwartz et al. 2018). Based on in-season weather data from 2011-2016, there were zero times that the cities received zero rainfall during a 28 or 35-day timespan. However, there were quite a few 28 and 35-day periods where cities received less than one inch of rainfall (Table 4). Athens received less than one-inch or less rainfall 11% of the time during 28 day stretches of time during 2011-2016, while having one-inch or less 5% of the time for 35-day stretches of time. Given this, ‘TifTuf’ may have a longer payback than other bermudagrass cultivars, but may sustain lawns from dying if no irrigation is applied.

Homeowners with more consistent watering regimes receive an increasing amount of savings. For instance, a homeowner in Atlanta would save 2.31 cm of water per 0.41 ha (one acre) per year and save \$171 dollars annually if they irrigated at 25% of water need. However, a homeowner irrigating at a 75% of the needed water rate would save \$686. Table 3 is not meant to advocate for increased or decreased watering, but rather to show expected savings and payback periods given varying irrigation levels.

In summary, ‘TifTuf’ appears to provide a significant cost and water savings for homeowners in the selected cities. As shown by the simulation, homeowners with higher water rates and less rain see a return on their investment in ‘TifTuf’ relatively soon, which would allow

them to begin saving money every month once the premium is paid off. The average annual cost savings in the Southeastern cities is around \$799 with the average annual water savings averaging 12.88 cm (five inches) of water per 0.41 ha (one acre). Average payback was around three years for a new lawn and 20 years for a replacement lawn. Cities outside of the Southeast had higher water and cost savings due to less rainfall and/or higher water rates.

While cost savings, water savings, and payback period suggest that ‘TifTuf’ would be a good investment for homeowners, especially when installing a new lawn, the issue will be to convince homeowners that ‘TifTuf’ will in fact have positive effects for them. Homeowners are becoming more environmentally conscious (Curtis and Cowee 2010), which implies ‘TifTuf’ fits with the views of many homeowners. Further, ‘TifTuf’'s ability to survive with less to no water for long periods of times would appeal to homeowners that do not irrigate. Due to ‘TifTuf’'s potential savings ability along with the other positive attributes that it contains, the installation of ‘TifTuf’ by a contractor, homeowner, or a school on an athletic field would seemingly be a good financial investment, though, other considerations such as a homeowners’ views on irrigation amounts and the planting location (e.g., shade vs. sunlight, amount of traffic, etc.) should be considered.

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