Title: Development of Environmentally Sustainable, High Quality Turfgrasses through On-Site Golf Course Research

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Objectives:

1. Evaluation of advanced experimental turfgrasses for putting greens under realistic management intensity and performance expectations.
2. Continuation of a GGEF sponsored student worker position in the UGA Turfgrass Breeding Program at Tifton, GA.

Start Date: 2016

Project Duration: 7 years (2016 – Present)

Total Funding: $72,000 to date

Summary Points:

1. 12-TG-101, an interspecific triploid hybrid bermudagrass (*Cynodon transvaalensis* × *C. dactylon*), was released from the University of Georgia's College of Agricultural & Environmental Sciences during the fall of 2021 and named 'Tif3D' during 2022.
2. 'Tif3D' generally has superior turf uniformity to 'TifEagle' during, or immediately following, many environmental (drought, disease, and temperature fluctuations during the spring and fall) or mechanical (mower scalping, verticutting, and hollow-core aeration) stresses.
3. 'Tif3D' has a very dark green leaf that should distinguish it from other ultradwarf cultivars, including 'TifEagle', 'MiniVerde', and 'Champion'.
4. 'Tif3D' has equal putting green speeds as 'TifEagle', the most widely used ultradwarf bermudagrass cultivar in the world.

Summary Text:

Bermudagrasses can be found on golf course putting greens throughout the southern United States. Before genetic improvement of these species began, greens were planted from seed which provided golfers with very inconsistent putting surfaces (Burton, 1977). Modern expectations of putting greens include consistent and fast ball roll, which can be accomplished by growing a uniformly smooth, short and dense turf canopy. In 1946, the United States Golf Association's Green Section supported research at Tifton, GA in collaboration with the United States Department of Agriculture – Agricultural Research Services to create new grasses for golf courses. The annual $500 USGA grant allowed the USDA-ARS to accumulate turf-type bermudagrass germplasm through the creation of lower growing genotypes with higher canopy density from the forage breeding efforts in addition to the collection of golf course adapted selections (Burton, 1991).

'Tifgreen'(2*n*=3*x*=27) was an improved triploid interspecific hybrid bermudagrass developed by crossing *Cynodon transvaalensis* (2*n*=2*x*=18) and a *C. dactylon* (2*n*=4*x*=36) selection that demonstrated good putting green characteristics on the Charlotte Country Club in North Carolina (Burton, 1964). 'Tifgreen' has been reported to be a pollen and seed sterile cultivar. A few years after its release, several off-types were identified on golf greens planted with 'Tifgreen' and sent back to the Tifton USDA-ARS research program for analysis. It was determined that these off-types were not contaminations from seed, but vegetative mutations (Burton and Elsner, 1965). One of these off-types was eventually released as 'Tifdwarf' (1964), which proved to be no more genetically stable than 'Tifgreen'. In the years following there were numerous 'Tifgreen' derived cultivars released from multiple institutions, including 'Pee Dee 102' (1968), 'Champion Dwarf' (1987), 'MiniVerde' (1992), 'Floradwarf' (1995), 'TifEagle' (1997), 'MS-Supreme' (1997), and 'Mach 1' (2018).

'Tifgreen' was planted on the putting greens at Taylor's Creek Golf Course at Fort Stewart in Georgia during 1961. Fifty-one years later on 13 April 2012, 155 presumed mutants of the original 'Tifgreen' bermudagrass were collected from the home of the U.S. Army's 3rd Infantry Division (O'Brien, 2012). 'Tif3D' was one of 14 selections from the 13th green, which was plagued with shade and poor air movement (Figure 1).

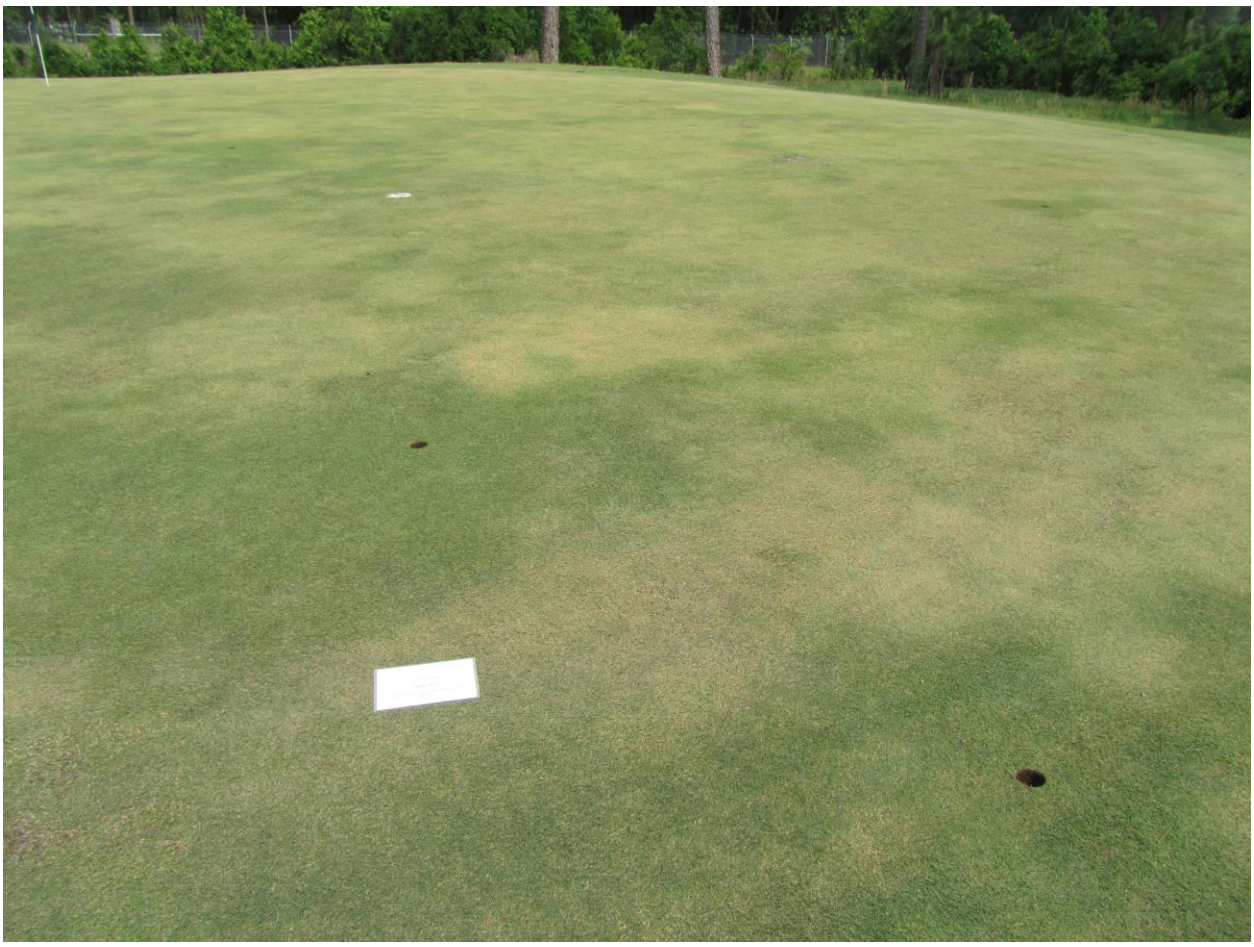

Figure 1. Samples were collected from the darker green, low-growing 'Tifgreen' mutants on the 13th putting green at Taylor's Creek Golf Course at Fort Stewart in Georgia during 2012.

Two identical, replicated field trials were established in 2013 and 2014 at the University of Georgia Tifton Campus where inflorescence, morphological, and turfgrass performance observations were recorded on these 155 putative somatic mutants for comparison with the bermudagrass cultivars 'Tifgreen', 'Tifdwarf', 'Champion Dwarf', 'MiniVerde', and 'TifEagle'. 'Tif3D' was highly adapted to the management conditions of the research trials in Tifton, although they are notably of lower-intensity than what is possible on golf courses with more resources. Therefore, 'Tif3D' was selected to be planted in 10 on-site golf course research putting green trials in the Southeastern United States from 2015 through 2019 for evaluation of turf color, turf uniformity, and putting green speeds against 'TifEagle' under standard maintenance protocols not possible on the Coastal Plain Experiment Station. The golf courses that hosted these trials were the Country Club of Columbus in Columbus, GA (2015); The Landings Club in Savannah, GA (2015); Valdosta Country Club in Valdosta, GA (2016); Atlanta Country Club in Marietta, GA (2016); Big Canoe Golf Course in Jasper, GA (2017); TPC Sawgrass in Ponte Vedra Beach, FL (2017); Streamsong Golf Resort in Bowling Green, FL (2018); East Lake Golf Club in Atlanta, GA (2019); Olde Florida Golf Club in Naples, FL (2019); and The Meadows Country Club in Sarasota, FL (2019).

Table 1. Summary of putting green performance of 12-TG-101 bermudagrass compared to TifEagle bermudagrass measured between 2015 – 2021 on 10 golf courses in the Southeastern United States[1].

Genotype	Year of release	Turf color[2]	Turf uniformity[3]	Green speed[4]
		visual rating	visual rating	ft
12-TG-101	2021	7.6 a[5]	7.6 a	9.4 a
TifEagle	1997	6.4 b	6.9 b	9.2 a

[1]Field trials planted between 2015 – 2019 at the Country Club of Columbus, The Landings Club, Valdosta Country Club, Atlanta Country Club, Big Canoe Golf Course, TPC Sawgrass, Streamsong Golf Resort, East Lake Golf Club, Olde Florida Golf Club, and The Meadows Country Club.
[2]Turf color was visually rated on a 1 to 9 scale with 1 = yellow, 6 = acceptable, and 9 = dark green.
[3]Turf uniformity was visually rated on a 1 to 9 scale with 1 = least, 6 = acceptable, and 9 = most. Putting green surface leaf density, leaf width, leaf canopy distribution, leaf orientation, leaf mowing quality, and weed encroachment were all taken into consideration for the comprehensive turf uniformity visual rating.
[4]Green speeds were determined by measuring the distance golf balls rolled when released from an inclined plane called a Stimpmeter (United States Golf Association, 1979).
[5]Least squares means within columns followed by the same letter are not significantly different according to the Tukey-Kramer test ($P < 0.05$).

Data presented in Table 1 were analyzed by restricted maximum likelihood using PROC MIXED in SAS 9.4 (Littell et al., 2006). A Kenward–Rodgers adjustment was applied to correct the denominator degrees of freedom, ensuring appropriate standard errors and F statistics for each model. Multiple covariance structures were tested and the Bayesian's Information Criterion indicated that Autoregressive (1) was the best fit. Fixed effects included genotype, year of trial maturity, and season of year (winter, spring, summer, and fall). Each golf course trial was considered a replicate and was designated as a random effect. Other random effects were sprig source (research farm or sod farm), existing cultivar being managed on the golf course greens ('TifEagle', 'MiniVerde', 'Tifdwarf', or bentgrass), and the subsoil of the research greens (new profile or no-till profile). Means were compared using the LSMEANS procedure with Tukey–Kramer adjustment ($P < 0.05$). Differences were considered significant at $P < 0.05$. No genotype × year of trial maturity, or genotype × season of year interactions were detected (data not shown). Across the golf course putting green performance trials, 'Tif3D' was visually darker green and

more uniform than 'TifEagle', but had the same green speeds as determined with a USGA Stimpmeter (Table 1).

Figure 2. Different genotypic response to mower scalping on adjacent golf greens plots of 'Tif3D' (A) and 'TifEagle' (B) after a 2-month (A/B) and 5-month (C/D) sustained period of lower agronomic maintenance intensity at the Olde Florida Golf Club in Naples, FL. Trial planted on 18 September 2019.

Although 'TifEagle' remains the most utilized and genetically stable ultradwarf bermudagrass cultivar across the world, advances in golf putting green uniformity and ball roll consistency are always needed, especially after mechanical injury (Figure 2), or when disease pressures are high (Figure 3).

Figure 3. Different genotypic response to take-all root rot (*Gaeumannomyces graminis*) on adjacent plots of 'Tif3D' (A) and 'Mach 1' (B) at East Lake Golf Club in Atlanta, GA on 9 June 2021 after hollow-core aeration in late May 2021. Trial planted on 1 May 2019.

'Tif3D' has been tested for broad adaptation in areas of the Southeastern United States where warm-season grasses are grown on golf putting greens and should also benefit those in regions of the world where 'TifEagle' has previously been successful. A 5,400 ft^2 Breeder Field and a 1-acre Foundation Field of 'Tif3D' have been established (Figure 4). Planting of sprig and sod production fields is set for early 2023, with a limited supply of 'Tif3D' predicted to be available for sale to consumers in late 2023 or early 2024.

Figure 4. The 1-acre George Seed Development Foundation Field of 'Tif3D' located at Pike Creek Turf in Adel, GA. Field planted on 14 May 2021.