

# Bermudagrasses Show Diverse Responses to Shade

By C.M. Baldwin and H. Liu

**T**rees out-compete turfgrasses for light, water and nutrients. However, the response of different cultivars to shade varies widely.

Trees are not going away from golf courses any time soon. They provide shade for players; make land use more efficient by separating fairways; increase golf course difficulty; enhance aesthetic value by screening roads, cars and buildings; protect errant shots from hitting pedestrians or cars; and provide a natural wildlife sanctuary and habitat for birds (Lilly, 1999).

Regardless of the shade source, turfgrass growth and development are inhibited when plant light interception is suboptimal. An estimated 25 percent of turfgrass growth is impacted by light restrictions (Beard, 1997).

Bermudagrass (*Cynodon* spp.) decline in shade can be attributed to excessive shoot production. Beard and Beard (2005) define shade as, "a turfed or ground surface overshadowed by plant foliage such as a tree canopy or by an opaque structure; typically the interception of sunlight occurs."

When light is blocked, bermudagrass stoloniferous growth slows and vertical growth is initiated in search of sunlight. Due to this morphological change, bermudagrass depletes carbohydrate reserves and severely reduces its recuperative ability from daily mowing, traffic and divots. Cultural practices to enhance turfgrass performance in shade include raising mowing heights (Bunnell and McCarty, 2004), applying plant growth regulators (Bunnell and McCarty, 2004), and reducing nitrogen rates (Bell and Danneberger, 1999).

Bermudagrasses are the most popular warm-season turfgrass in warmer climate zones in the country (Shearman, 2006). In order to assist turfgrass managers when



*Visual quality comparison of TiftNo.4 (left) and Tifway following five weeks of 64 percent continuous shade.*

selecting bermudagrass for establishment or for renovation when shade is a limiting growth factor, a study was initiated at Clemson University to determine how 64 percent continuous shade impacted 42 bermudagrass cultivars' growth and development.

## Materials and methods

This two-year greenhouse study was conducted from June 15, 2005 to Aug. 15, 2005, and repeated in 2006 at Clemson University. The study included two treatments, a control (full sun) and 64 percent continuous shade, applied daily using a neutral density, polyfiber black shade cloth.

Shade cloths were placed on a polyvinyl chloride (PVC) structure 6 feet in length and 5 feet in diameter with 1-inch diameter PVC pipes. Shade tents were placed 1 foot above the turfgrass surface to reduce sunlight encroachment in early morning and late afternoon.

Plugs were collected from the 2002 Bermudagrass National Turfgrass Evaluation Program (NTEP) (Table 3, p.64) field research plots located at Clemson University and transplanted into cone-tainers with 85 percent sand

*Continued on page 60*

Enhance turf performance in shade by raising mowing heights, applying growth regulators and reducing nitrogen rates.

TABLE 1

Turfgrass quality of 42 bermudagrass cultivars after four and eight weeks of full-sun (control) and 64 percent continuous shade at the Clemson University greenhouse complex. NTEP turf quality (1 to 9).

Cultivar	----- Turfgrass Quality -----				Rank <sup>†</sup>
	Week 4		Week 8		
	Full Sun	Shade	Full Sun	Shade	
Celebration	7.5a-c <sup>‡</sup>	6.5ab	7.3a-d A	4.5a-c B	2/2
TiftNo.4	7.3a-d	6.2a-d	7.8a A	4.8ab B	2/2
TiftNo.1	7.2b-e	6.3a-c	7.2a-d A	4.3a-d B	2/2
Transcontinental	7.0c-f	6.0a-e	6.8b-f A	4.3a-d B	2/2
Aussie Green	7.5a-c	7.2a	7.8a A	5.3a B	2/2
MS-Choice	6.8c-g A <sup>§</sup>	5.8b-e B	7.3a-d A	3.7c-h B	0/2
Princess 77	7.2b-e A	5.3b-h B	6.8b-f A	3.7c-h B	0/2
SWI-1045	7.2b-e A	5.5b-g B	7.0a-e A	3.7c-h B	0/2
SWI-1041	7.8ab A	5.3b-h B	7.3a-d A	3.5c-i B	0/2
SWI-1012	7.0c-f A	5.3b-h B	7.0a-e A	4.0b-f B	0/2
Tifway	7.5a-c A	5.0d-i B	7.5a-c A	3.2e-i B	0/2
Tifsport	7.2b-e A	5.5b-g B	7.7ab A	3.3d-i B	0/2
SWI-1014	7.5a-c A	5.5b-g B	7.2a-d A	3.2e-i B	0/2
GN-1	6.2g-j A	4.5f-i B	6.2e-g A	3.2e-i B	0/2
Patriot	6.3f-i A	4.5f-i B	6.5d-f A	2.5i B	0/2
Sundevil	6.7d-h A	5.0d-i B	6.8b-f A	3.7c-h B	0/2
SR 9554	6.3f-i A	4.8e-i B	6.7c-f A	3.0f-i B	0/2
Arizona Common	5.5j A	4.2hi B	5.5g A	3.0f-i B	0/2
p-value	0.0001 <sup>f</sup>	0.0001	0.0001	0.0001	

<sup>†</sup> Rank indicates number of times cultivar placed in top statistical category when grown under 64 percent shade. Greatest shade tolerance = 2/2, greatest shade sensitivity = 0/2.

<sup>‡</sup> Values within a column followed by the same letter are not significantly different at P≤0.05 by protected LSD.

<sup>§</sup> Values within a row within each week for turfgrass quality followed by the same letter are not significantly different at P≤0.05 by protected LSD.

<sup>f</sup> Indicates statistical difference at p≤0.05.

\* For a complete list of results from all cultivars, please e-mail: [cmbaldw@clemson.edu](mailto:cmbaldw@clemson.edu)

PHOTO 2



Root biomass comparison of Celebration (left) and Tifway bermudagrasses following eight weeks of 64 percent continuous shade.

Continued from page 59

and 15 percent peat as growth media. Container dimensions were 10 inches in height and 2 inches in diameter. Following potting, plugs were established one month prior to treatment initiation. Fertilizers were provided at 1 pound nitrogen (N) per 1,000 square feet biweekly using a complete fertilizer (16N-1.7P-6.6K). Containers were mowed 0.5 inches four times weekly with clipping removal.

Data collection was identical in year one and year two. Turfgrass quality ratings were recorded weekly based on color, density, texture and uniformity of the bermudagrass surface. Quality was visually evaluated from 1 to 9 — 1 = brown, dead turf; 6 = minimal acceptable turf; 9 = ideal green, healthy turf.

**By week eight, all cultivars grown in shade had significant decline in turf quality compared to those grown in full sun.**

Root biomass and length were determined at the end of the study. Roots were extracted from the soil and thoroughly washed until all soil was removed. Following soil removal, root length was measured from the base of the thatch level and recorded. Roots were then clipped from the base of thatch and dried in an oven at 176 degrees Fahrenheit for 48 hours. Once dried, samples were weighed to determine total root biomass.

Total shoot chlorophyll concentration was measured at weeks four and eight. Clippings (0.1 grams) were collected from each container and placed in a glass test tube with 10 milliliters (ml) of dimethyl sulfoxide. Samples were incubated in 149-degree F water for 1.5 hours. Remaining extract (2 ml) was transferred into cuvettes and absorbancy values were recorded at 663 nanometers (nm) and 645 nm wavelengths using a spectrophotometer.

Each treatment was replicated three times in a randomized complete block design. All statistical computations were conducted

Continued on page 62

TABLE 2

Turfgrass quality of 42 bermudagrass cultivars after four and eight weeks of full sun (control) and 64 percent continuous shade at the Clemson University greenhouse complex. NTEP turf quality (1 to 9).

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	Week 4		Week 8		
	Full Sun	Shade	Full Sun	Shade	
Celebration	7.5a-c <sup>‡</sup>	6.5ab	7.3a-d A	4.5a-c B	2/2
TiftNo.4	7.3a-d	6.2a-d	7.8a A	4.8ab B	2/2
TiftNo.1	7.2b-e	6.3a-c	7.2a-d A	4.3a-d B	2/2
Transcontinental	7.0c-f	6.0a-e	6.8b-f A	4.3a-d B	2/2
Aussie Green	7.5a-c	7.2a	7.8a A	5.3a B	2/2
MS-Choice	6.8c-g A <sup>§</sup>	5.8b-e B	7.3a-d A	3.7c-h B	0/2
Princess 77	7.2b-e A	5.3b-h B	6.8b-f A	3.7c-h B	0/2
SWI-1045	7.2b-e A	5.5b-g B	7.0a-e A	3.7c-h B	0/2
SWI-1041	7.8ab A	5.3b-h B	7.3a-d A	3.5c-l B	0/2
SWI-1012	7.0c-f A	5.3b-h B	7.0a-e A	4.0b-f B	0/2
Tifway	7.5a-c A	5.0d-l B	7.5a-c A	3.2e-i B	0/2
TifSport	7.2b-e A	5.5b-g B	7.7ab A	3.3d-i B	0/2
SWI-1014	7.5a-c A	5.5b-g B	7.2a-d A	3.2e-i B	0/2
GN-1	6.2g-j A	4.5f-i B	6.2e-g A	3.2e-i B	0/2
Patriot	6.3f-i A	4.5f-i B	6.5d-f A	2.5i B	0/2
Sundevil	6.7d-h A	5.0d-l B	6.8b-f A	3.7c-h B	0/2
SR 9554	6.3f-i A	4.8e-i B	6.7c-f A	3.0f-i B	0/2
Arizona Common	5.5j A	4.2hi B	5.5g A	3.0f-i B	0/2
p-value	0.0001 <sup>f</sup>	0.0001	0.0001	0.0001	

<sup>†</sup> Rank indicates number of times cultivar placed in top statistical category when grown under 64 percent shade. Greatest shade tolerance = 2/2, greatest shade sensitivity = 0/2.

<sup>‡</sup> Values within a column followed by the same letter are not significantly different at P≤0.05 by protected LSD.

<sup>§</sup> Values within a row within each week for turfgrass quality followed by the same letter are not significantly different at P≤0.05 by protected LSD.

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Continued from page 60

using analysis of variance (ANOVA) within the Statistical Analysis System. An alpha of 0.05 was used to determine any statistical significance among treatments.

**Tested cultivars produced significantly higher chlorophyll concentrations at week four when grown in shade, but this response proved to be transient.**

### Turfgrass quality

By week four, poorest-performing cultivars included GN-1 (4.5), Patriot (4.5) and Arizona Common (4.2), while Aussie Green (7.2), Celebration (6.5), TiftNo.4 (6.2), TiftNo.1 (6.3) and Transcontinental (6.0) main-

tained acceptable turf quality (TQ) ratings following four weeks of 64 percent shade (Table 1, p. 60).

In a previous study, Celebration was noted for its relative shade tolerance compared to other bermudagrass cultivars (Bunnell et al., 2005). Industry standards, Tifway and TifSport, had TQ scores of 5.0 and 5.5, respectively. Results agree with Jiang et al. (2004) as TifSport bermudagrass was deemed shade sensitive when compared to various seashore paspalum cultivars.

After eight weeks of continuous 64 percent shade, all cultivars had severe tissue discoloration (Table 1). However, Aussie Green (5.3), TiftNo.4 (4.8) and Celebration (4.5) maintained significantly higher TQ scores compared to Patriot (2.5), SR 9554 (3.0) and Arizona Common (3.0). Gaussoin et al. (1988) also noted Arizona Common as highly shade-intolerant when compared to 31 other bermudagrass cultivars.

Transcontinental, Aussie Green, Celebration, TiftNo.4 and TiftNo.1 were the only cultivars not to show a significant decline in TQ by week four when grown in shade compared to full sun. However, at week eight all cultivars grown in shade had a significant decline in TQ compared to full-sun.

### Chlorophyll, root length

The shade-grown cultivar with highest chlorophyll concentration was TiftNo.4 at week four (2.47) and week eight (2.77), while TifSport and Arizona Common had lowest chlorophyll concentrations at week four (1.54) and week eight (1.31), respectively (Table 2). In shade, SWI-1041, Princess 77 and TiftNo.1 had 28-percent greater chlorophyll than Tifway, GN-1 and SWI-1014 at week four. By week eight, SWI-1012 and SWI-1045 had 52-percent greater chlorophyll when grown in shade than GN-1 and SWI-1014.

Interestingly, cultivars produced significantly higher chlorophyll concentrations at week four when grown in shade, however, this response was transient (Table 2). By week eight, most cultivars chlorophyll concentration declined. Greatest decline for shade-grown

Continued on page 64

TABLE 3

Overall shade tolerance rank of 42 bermudagrass cultivars after 8 weeks of full sun (control) and 64 percent continuous shade at the Clemson University greenhouse complex.

Cultivar	Rank <sup>†</sup>	Cultivar	Rank
Celebration	6	Mohawk	1
TiftNo.4	5	SWI-1001	1
TiftNo.1	5	Tifway	1
Transcontinental	5	Midlawn	1
SWI-1003	4	TifSport	1
Sunbird	4	OR 2002	1
Aussie Green	3	Ashmore	1
MS-Choice	3	CIS-CD5	1
Princess 77	3	CIS-CD6	1
SWI-1045	3	CIS-CD7	1
SWI-1041	3	Panama	1
SWI-1012	3	La Paloma	1
B-14	2	Yukon	1
Riviera	2	OKC 70-18	1
SWI-1046	2	NuMex Sahara	1
TiftNo.3	2	SWI-1014	0
Southern Star	2	GN-1	0
TiftNo.2	2	Patriot	0
Sunstar	1	Sundevil	0
SWI-1044	1	SR 9554	0
FMC-6	1	Arizona Common	0

<sup>†</sup>Rank indicates number of times a cultivar placed in the top statistical category when grown under 64 percent continuous shade. Greatest shade tolerance = 6, greatest shade sensitivity = 0.



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#### QUICK TIP

For fast disease-control efficacy at very low rates, use Compass® fungicide to control brown patch, anthracnose, leaf spot and gray leaf spot, among other turf diseases.

A broad-spectrum strobilurin fungicide, Compass has a mesostemic mode of action, delivering the value of a contact with the power of a systemic.

Continued from page 62

cultivars compared to full sun was SWI-1014, with a 76-percent decline, while Aussie Green only had a 29-percent reduction.

Cultivars grown under 64 percent shade showed little root-length variation, however, differences were statistically different. The most striking difference was TifSport producing 75 percent greater root length than Arizona Common. Overall, root length was least affected by shade compared to other parameters measured. Shade-grown cultivars, Arizona Common, SWI-1014 and Sundevil had 63-percent, 59-percent, and 41-percent decreases, respectively, compared to control (full sun).

Root biomass was severely restricted when cultivars were grown under 64 percent shade. MS-Choice, Transcontinental and Celebration produced about 158 percent greater root biomass than GN-1, Arizona Common and SR 9554.

Each cultivar, regardless of shade tolerance

or sensitivity, had a significant reduction in root biomass. Aussie Green grown in shade had least root mass reduction (133 percent) compared to full sun, while SWI-1014 had greatest root mass decline (332 percent) compared to full sun.

Results indicate the genetic variability of shade tolerance exists among bermudagrasses and future bermudagrass improvement focusing on shade tolerance is promising. Bermudagrass cultivars, in particular newer commercially available and experimental ones, demonstrated great genetic diversity. Based on rank of significant parameters (TQ, chlorophyll, root biomass and root length), the best cultivars were Celebration, TiftNo.4, TiftNo.1 and Transcontinental. Cultivars with intermediate shade tolerance included Aussie Green, MS-Choice, Princess 77, SWI-1045, SWI-1041 and SWI-1012. Most shade-sensitive cultivars were SWI-1014, Arizona Common, Sundevil, SR 9554, GN-1 and Patriot.

Future research will further analyze the relatively shade-tolerant and shade-intolerant cultivars to provide insight into the physiological mechanisms associated with such variation that exists among bermudagrass shade responses.

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