Turf covers for winter protection of bermudagrass greens

Turf covers varied significantly in the range of daily temperatures they produced and the levels of photosynthetically active radiation they transmitted.

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Winterkill is one of the greatest challenges facing superintendents managing bermudagrass (*Cynodon* species) greens in the highly variable climates of the transition zone and mid-South regions of the U.S. Recent improvements in bermudagrass density and tolerance to cutting heights of 0.12 inch (3 millimeters) or less have increased the use of these grasses for putting green turf. However, the tolerance of these grasses to low mowing heights is also coupled with a reduction in freeze tolerance, suggesting increased potential for winterkill (1).

Turf covers

Turf covers perform much like a cloud canopy, modifying the levels of solar radiation transmitted to the earth and trapping radiant energy that is trying to escape to the atmosphere. Researchers have examined the effect of different types of covers on winter survival of annual bluegrass (*Poa annua* L.) and creeping bentgrass (*Agrostis palustris* Huds.) greens and on bermudagrass greens maintained at cutting heights of 0.75 inch (19 millimeters) or higher (4,6,7,8). In all these cases, the covers were in place for a period of consecutive months, removing the turf from play. Because golf can be played throughout much of the winter in areas where bermudagrass is adapted, turf covers are often applied to putting greens on a temporary basis to provide short-duration, low-temperature protection.

However, little published research details how covers modify the surface temperatures of bermudagrass greens. The objectives of this research were to determine how various commercially available and experimental cover materials modify surface temperatures of a bermudagrass green when covers are applied before predicted severe winter temperatures, and to determine the extent to which the turf covers reduce the levels of photosynthetically active radiation at the turf surface.

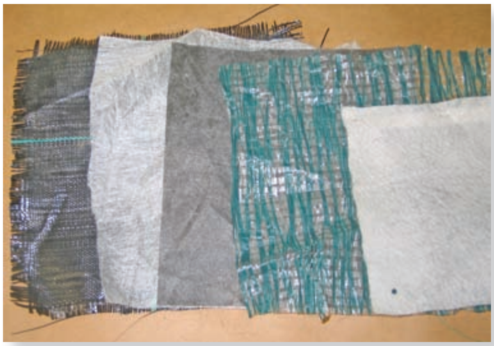
Research site and maintenance

The research was conducted on a bermudagrass practice green planted with MS-Express (*Cynodon magenissii* Hurc.) and maintained at a 0.18-inch (4.5-millimeter) cutting height on a 90% USGA-recommended sand/10% composted rice hull (volume/volume) soil mix at the Mississippi State University Golf Course during the winters of 2000-2001, 2001-2002 and 2002-2003.

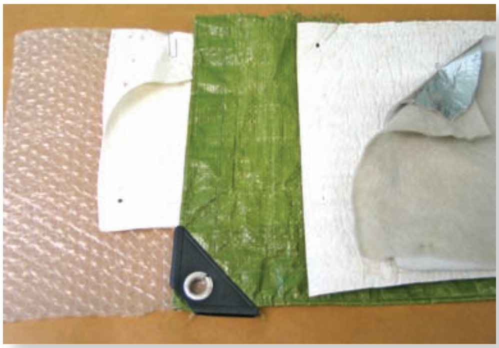
The turf received nitrogen and potassium at approximately 10 pounds/1,000 square feet (488 kilograms/hectare) per growing season. Other nutritional adjustments were applied according to soil test recommendations or as the superintendent deemed necessary (soil pH during the trials ranged from 6.8 to 7.1). Irrigation and other cultural programs (core cultivation, topdressing, rolling, etc.) were applied according to the superintendent's discretion to maintain healthy turfgrass growth and desirable playing characteristics.

Covers and temperature recording techniques

The materials presented in Table 1 (listed both as standard commercially available covers and experimental covers specific to this research) and shown in the photos were evaluated across the three yearly trials. Each cover measured approxi-



Left: Commercially available covers used in this trial. **Left to right:** black woven polypropylene (BX); white (WT1) and black (BT1) spunbonded polypropylene; an interwoven translucent polyethylene (EG) cover; and a gray, nonwoven geotextile (SL).



Right: Experimental covers used in this trial. **Left to right:** translucent horticultural thermal blanket (OB); three polypropylene microfoam sheets with a laminated backing (PPS); a green polyethylene tarpaulin (Tarp); a single polypropylene microfoam sheet with laminated backing (PPF); and a 2-millimeter-thick reflective film attached to a nonwoven geotextile (SLR). **Photos by M. Goatley**

mately 9.8 feet × 9.8 feet (3 × 3 meters) and was installed with sod staples. A 9.8-foot × 9.8-foot (3-meter × 3-meter) area of uncovered turf was used as the control treatment.

Covers were applied at the discretion of the superintendent of Mississippi State University Golf Course (Pat Sneed, CGCS) when minimum predicted temperatures of 24.8 F (-4 C) or less (based on area National Weather Service forecasts) were forecast for at least two consecutive evenings. Based on this criterion, dates when covers were applied in the three yearly trials were:

- Dec. 2, 2000-Jan. 6, 2001, and Jan. 20-23, 2001, during the 2000-2001 trial
- Dec. 29, 2001-Jan. 4, 2002; Jan. 7-9, 2002; and Feb. 26-March 1, 2002, during the 2001-2002 trial
- Jan. 11-14, 2003, and Jan. 17-28, 2003, during the 2002-2003 trial

Data loggers were used to record temperatures under each cover at 15-minute intervals. The temperature data are presented in the following three categories: mean of the range in daily surface temperatures, mean of the daily maximum surface temperature, and mean of the daily minimum surface temperature.

Soil-surface photosynthetically active radiation (micromols/square meter/second) measurements for all cover treatments were made with a photometer. The data were collected under a cloudless sky from 11:00 a.m. to 11:15 a.m. on Oct. 21, 2003.

The experimental design was a randomized complete block with three replications per treatment. Because of a significant interaction between cover treatment and year, data are presented for each seasonal trial.

Turf covers

Cover source	Abbr.	Description	Supplier
Typar Black†	BT1, BT2	spunbonded polypropylene 3301B (single and double layers)	Reemay Inc., Old Hickory, Tenn.
Typar White†	WT1, WT2	spunbonded polypropylene 32N01 (single and double layers)	
Xton Black†	BX	woven polypropylene	Xton Inc., Florence, Ala.
Evergreen†	EG	interwoven, UV-treated, translucent polyethylene	Covermaster Inc., Rexdale, Ontario, Canada
SL500†	SL	gray, nonwoven geotextile	Sur-Line Turf Inc., Northport, Ala.
SL 500† + reflective backing‡	SLR	gray, nonwoven geotextile with 2-millimeter-thick reflective film attached to underside	
Overwintering blanket‡	OB	translucent air-bubble sheet marketed as a horticultural thermal blanket	Pactiv Corp., Lake Forest, Ill. (formerly Tenneco Packaging)
Polypropylene sheets with laminated ultraviolet radiation inhibiting (uvi) backing‡	PPS	0.6-centimeter total thickness material composed of a laminated, uvi backing secured to three sheets of polypropylene microfoam of approximately 0.15-centimeter thickness	
Expanded polypropylene foam with laminated uvi backing‡	PPF	0.6-centimeter total thickness material composed of laminated, uvi backing secured to a single sheet of 0.45-centimeter thick expanded microfoam	
Tarp†	Tarp	commercially available green polyethylene tarpaulin	Wal-Mart Inc., Bentonville, Ark.
No cover	Control	uncovered control	—

†Commercially available.
‡Experimental cover.

Table 1. Turf cover source, abbreviations used in text, cover description, and product supplier.

Cover effects on radiation and spring green-up

Reductions in photosynthetically active radiation were 87% or greater for all black covers (BT1, BT2, BX) and the experimental SLR and PPS. The standard Tarp, EG, PPF and SL moderately reduced photosynthetically active radiation (64% to 79%); this reduction might be of concern for turf growth, but would offer greater flexibility in covering duration. The least reduction in photosynthetically active radiation occurred with the white covers (WT1, 36%; and WT2, 49%) and clear overwintering blanket (OB, 34%).

Covers that significantly restrict photosynthetically active radiation will likely limit rapid spring bermudagrass regrowth from dormancy. Translucent covers have been shown to accelerate spring transition from dormancy to active growth when applied for the duration of the winter months (4,6,8). However, significant visible greening enhancement was not evident in our trials, possibly because of the limited duration of cover applications based on temperature fluctuation and relatively mild winter weather patterns (data not shown). Further research is required to determine how bermudagrass growth is affected by reduced photosynthetically active radiation levels as a result of longer-term covering.

Moderation of temperatures by covers

Overwintering blanket

The overwintering blanket (OB) provided the highest daily mean maximum, minimum, and range in temperatures of all cover treatments (Tables 2-4). This cover source, a translucent material similar to commercial bubble wrap, performed comparably to clear plastic covers previously tested in Virginia and Maryland (6,8). Use of the overwintering blanket resulted in daily mean maximum temperatures that were at least 5.8 F (3 C) higher than the next highest cover treatment temperature in any year and 10.8 to 14.4 F (6 C-8 C) warmer on average than the control. These data indicate that the overwintering blanket provided the best low temperature protection as well (Table 3), but the capacity for a rapid change in temperature (as indicated by the range data in Table 4) prompts concerns for leaving the overwintering blanket on for extended time periods in a climate where rapid temperature fluctuations are likely. A maximum temperature of 113 F (45 C) was recorded under the overwintering blanket treatment on Jan. 11, 2003, as compared to 51.8 (11 C) for the uncovered control (data not shown), a temperature that could possibly result in an untimely break in bermudagrass winter dormancy and/or loss of cold temperature acclimation if covers remained in place during warm weather conditions. The overwintering blanket was not modified to provide air and moisture exchange, and it is likely that venting the product could improve the flexibility in scheduling this cover's installation and removal frequency. Vented clear plastic sheeting delayed autumn dormancy, reduced freezing injury and hastened postdormancy growth of bermudagrass in Virginia (6).

Experimental covers

The other three experimental covers (SLR, PPF and PPS) had the lowest range in daily temperatures (Table 4). It was hypothesized that the reflective film backing added to the underside of the commercially available SL cover to make the SLR cover treatment would aid in trapping additional thermal radiation. The addition of the reflective material resulted in a significant mean minimum temperature increase of 4.9 F (2.7 C) over the SL treatment in 2001-2002 and 4.5 F (2.5 C) over the SL treatment in 2002-2003 (Table 3). The SLR provided the highest average daily minimum temperatures and consistently had some of the highest average daily mean and lowest average daily ranges in temperatures across the three years (Tables 3-4).

The lowest mean maximum temperature values were recorded for the experimental PPS, having mean temperatures similar to the control in all years (Table 2). PPS and PPF were effective for low temperature protection and likely would not require removal during warm weather patterns. However, they probably will not promote post-dormancy growth of bermudagrass as indicated by their low daily maximum temperature means (Table 2) and their low photosynthetically active radiation transmission values (<27%).

White covers

Among commercially available covers evaluated, the white covers (WT1 and WT2) tended to have the highest mean daily maximum temperatures after

Daily maximum mean temps

	2000-2001[‡]	2001-2002[‡]	2002-2003[‡]
Cover[†]	Maximum temperature F (C)		
OB	59.1 (15.1) a	59.1 (15.1) a	62.4 (16.9) a
BX	53.6 (12.0) b	51.4 (10.8) b	52.7 (11.5) bc
Tarp	52.3 (11.3) bc	51.1 (10.6) bc	52.9 (11.6) bc
WT1	51.4 (10.8) bcd	50.9 (10.5) bc	52.0 (11.1) bcd
BT2	51.3 (10.7) bcd	49.3 (9.6) bc	53.6 (12.0) bc
BT1	51.1 (10.6) bcde	49.5 (9.7) bc	50.7 (10.4) bcde
EG	50.4 (10.2) bcde	49.6 (9.8) bc	52.7 (11.5) bc
WT2	49.8 (9.9) bcde	52.0 (11.1) b	52.5 (11.4) bcd
PPF	48.0 (8.9) def	51.8 (11.0) b	51.1 (10.6) bcd
SL	47.7 (8.7) def	51.6 (10.9) b	51.8 (11.0) bc
SLR	47.5 (8.6) def	52.0 (11.1) b	49.6 (9.8) de
Control	47.1 (8.4) ef	49.6 (9.8) bc	47.8 (8.8) e
PPS	45.0 (7.2) f	48.2 (9.0) c	48.7 (9.3) e

[†] See abbreviations and descriptions of covers in Table 1.

[‡] Means within a column followed by the same letter are not significantly different from one another.

Table 2. Daily maximum temperature means under turf covers applied to a bermudagrass putting green for three years of research trials.

Minimum daily temps under covers

	2000-2001[‡]	2001-2002[‡]	2002-2003[‡]
Cover[†]	Minimum temperature F (C)		
SLR	35.2 (1.8) a	39.7 (4.3) a	40.6 (4.8) a
PPF	34.7 (1.5) ab	37.9 (3.3) abcd	38.3 (3.5) bc
WT2	34.0 (1.1) abc	37.9 (3.3) abcd	38.1 (3.4) bc
BT2	33.8 (1.0) abc	36.9 (2.7) bcde	36.7 (2.6) cde
PPS	33.8 (1.0) abc	38.8 (3.8) ab	37.9 (3.3) bcd
Tarp	33.4 (0.8) abc	33.3 (0.7) fg	37.8 (3.2) bcde
WT1	33.4 (0.8) abc	34.9 (1.6) ef	36.0 (2.2) e
OB	33.4 (0.8) abc	38.3 (3.5) abc	39.0 (3.9) ab
SL	33.1 (0.6) abc	34.9 (1.6) ef	36.1 (2.3) de
BX	32.9 (0.5) abc	35.6 (2.0) def	36.1 (2.3) de
EG	32.4 (0.2) bc	33.4 (0.8) fg	32.7 (0.4) f
BT1	30.6 (-0.8) cd	35.4 (1.9) ef	36.7 (2.6) cde
Control	29.3 (-1.5) d	32.0 (0.0) g	31.5 (-0.3) f

[†] See abbreviations and descriptions of covers in Table 1.

[‡] Means within a column followed by the same letter are not significantly different from one another.

Table 3. Minimum daily temperatures under turf covers applied to a bermudagrass green for three years of research trials.

the overwintering blanket in each of the three years (Table 2). WT2, which has two layers, as opposed to the single layer of cover material in WT1, had significantly greater average daily minimum than WT1 in 2001-2002 and 2002-2003, but the differences were still only 34 F (1.1 C) to 35.1 (1.7 C) (Table 3). WT2 tended to have a lower average daily temperature range than WT1 across all three years, but the differences were not significant (Table 4). The additive effects of a second layer of white Typar on temperature modification were minimal under these experimental conditions, and photosynthetically active radiation reduction was 49% for the double layer as compared to 36% for the single cover.

Evergreen cover

The EG cover tended to increase the mean daily maximum temperatures as compared to the control (Table 2), but average daily minimum temperatures were not significantly different from the control in two of the three years (Table 3). The EG cover placed in the second-lowest statistical grouping for average daily mean temperatures and the second highest statistical grouping for average daily temperature range in each year (Table 4). The visibly loose interweave of translucent polyethylene in the EG cover allowed for significant daytime heating, but much of the energy captured was lost during the evening hours.

Polyethylene tarp

The polyethylene tarp tended to provide some of the most variable temperature responses, with highly fluctuating mean daily minimum temperatures between years 1 and 3 as compared to year 2 (Table 3). We have no explanation for this variation. However, its mean daily maximum temperatures were consistently in the second highest statistical category in each year (Table 2) and its mean daily range temperature was in either the highest or second highest category each season (Table 4). Though widely available at many retail stores, tarps such as these have declined in popularity for temporary cold protection of bermudagrass greens because of their weight and handling characteristics. Still, this material provided desirable temperature modification characteristics comparable to other industry standard and experimental covers evaluated here.

Daily temp range

Cover[†]	2000-2001[‡]	2001-2002[‡]	2002-2003[‡]
	Daily range in temperatures F (C)		
OB	25.8 (14.3) a	20.9 (11.6) a	23.4 (13.0) a
BX	21.2 (11.8) ab	15.5 (8.6) bcdef	16.6 (9.2) bc
BT1	20.5 (11.4) ab	14.2 (7.9) bcdef	14.2 (7.9) cd
Tarp	18.7 (10.4) bc	17.8 (9.9) ab	15.1 (8.4) cd
WT1	18.0 (10.0) bcd	16.0 (8.9) bcde	16.0 (8.9) bcd
Control	17.6 (9.8) bcd	17.6 (9.8) abc	16.4 (9.1) bc
EG	17.6 (9.8) bcd	16.2 (9.0) bcd	20.0 (11.1) ab
BT2	17.3 (9.6) bcd	12.4 (6.9) ef	14.2 (7.9) cd
WT2	15.8 (8.8) bcde	14.0 (7.8) cdef	14.4 (8.0) cd
SL	14.4 (8.0) cde	16.7 (9.3) bcd	15.7 (8.7) c
PPS	13.3 (7.4) cde	13.9 (7.7) def	12.8 (7.1) cde
SLR	12.2 (6.8) de	12.2 (6.8) ef	9.2 (5.1) e
PPF	11.2 (6.2) e	9.4 (5.2) f	11.0 (6.1) de

[†] See abbreviations and descriptions of covers in Table 1.
[‡] Means within a column followed by the same letter are not significantly different from one another.

Table 4. Daily range in temperatures under turf covers applied to a bermudagrass green for three years of research trials.

Black covers

It was anticipated that the commercially available (BT1, BT2, BX) light-impermeable covers (90% or greater reduction in photosynthetically active radiation) might have a significant reduction in mean daily maximum temperatures caused by a "shade" effect. However, these covers consistently had some of the highest average daily maximum temperatures across the three years (Table 2). Doubling the black Typar spunbonded polypropylene cover (BT2) did not significantly affect any mean temperature variable measured as compared to the single black cover treatments BT1 or BX (a woven polypropylene) (Tables 2-4). There were no consistent patterns in temperature response between white or black Typar covers. Dark-colored rain covers resulted in the lowest turf-quality ratings when applied for winter protection of Kentucky bluegrass (*Poa pratensis* L.) (5), likely because the turf received inadequate photosynthetically active radiation. Research is needed to evaluate bermudagrass response to various colors of covers applied on a temporary basis for frost or extreme cold protection or applied as long-term seasonal protection for the winter months.

Nonwoven geotextile

The gray-colored nonwoven geotextile, SL500, reduced photosynthetically active radiation an additional 33% as compared to the single-layer white cover, WT1, but its temperature values were not statistically different from WT1 over the three years (Tables 2-4). Since the 1980s, this fabric has been popular in the mid-South of the U.S. for winter cover of bermudagrass greens (on a temporary and a permanent basis) because of its relative affordability and anticipated performance.

No covers

The lowest temperature recorded at the soil surface of the uncovered control plots of MS-Express bermudagrass across the three years was 23.4 F (-4.8 C). Laboratory trials in Oklahoma showed that standard putting green bermudagrass cultivars had predicted freeze tolerance levels of 23.4 F (-4.8 C) to 20.3 F (-6.5C) (1). Winterkill of bermudagrass is not solely caused by low temperature extremes. Bermudagrass also has been shown to be affected by the duration of the cold temperatures, limitations in physical and chemical properties of the soil, grass mowing height and nutritional levels, and slope aspect (2,3).

Future research

The MS-Express cultivar used in these trials is suited to regular mowing at 0.18 inch (4.5 millimeters), but other bermudagrasses can be mowed at 0.12 inch (3 millimeters) or less. These grasses need to be examined in future research.

Although few environmental extremes occurred during the three winter seasons in our trial, we anticipate the trends in temperature modification for the respective covers would be similar under more adverse environmental conditions and for other cultivars. Long-term covering trials that encounter a broad range of severe winter conditions conducive to winterkill are required to further distinguish the performance of the various covers.

Conclusions

Applying any form of cover on a temporary basis before anticipated temperatures of 24.8 F (≤ -4 C) or less resulted in an increase in average minimum temperatures as compared to the uncovered control. Therefore, coverage would likely improve turfgrass survival during periods of extreme low temperatures. Cover selection also should consider the levels of photosynthetically active radiation transmission and daily temperature range as both were found to be highly variable depending on cover composition, color, and to a smaller degree, cover thickness. Additionally, practical considerations such as cost, durability, weight (both wet and dry), handling and placement under windy conditions, and storage requirements also are important.

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Turf covers were tested at the Mississippi State University GC in the winter months from 2001 to 2003. **Photo by P. Sneed**

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GCM

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The research says

➔ Research trials were conducted on a bermudagrass green over the winter months of 2000-2003 to evaluate how various turf covers modify surface temperatures and turfgrass growth when applied for temporary cold temperature protection.

➔ Average daily maximum and minimum temperatures were recorded, as well as the average daily range in temperatures under covers.

➔ Temperature responses varied with cover composition, permeability, color and, to a lesser extent, thickness.

➔ An experimental translucent overwintering blanket provided the highest average daily maximum temperatures, but also had the greatest temperature range, indicating the potential for excessive heating under the cover.

➔ A commercially available interwoven polyethylene cover also provided high daily mean soil surface temperatures, but its mean daily minimum temperatures were not significantly different from the uncovered control in two of the three years, apparently indicating much of the energy acquired during the day was lost after sundown.

➔ Doubled layers of commercially available white or black polypropylene covers had only slightly increased mean daily minimum temperatures as compared to single layers.

➔ All covers provided some degree of potentially desirable temperature modifications, but selection and use would depend on the particular needs of the superintendent.