Colorant Application Volume and Color Persistence on a 'Chisholm' Zoysiagrass Lawn

Ross Braun[1,3], Jack Fry[1], Megan Kennelly[2], Dale Bremer[1], and Jason Griffin[1]

Additional index words. paint, turfgrass, winter color, dormancy, turf colorant

Summary. Zoysiagrass (*Zoysia* sp.) is a warm-season turfgrass that requires less water and fewer cultural inputs than cool-season grasses, but its widespread use by homeowners in the transition zone may be limited because of its extended duration of brown color during dormancy. Turf colorants are an option for improving zoysiagrass winter color. Our objective was to quantify the impact of colorants applied in autumn at three application volumes on persistence of green color on lawn-height 'Chisholm' zoysiagrass (*Zoysia japonica*). The commercial colorants Green Lawnger, Endurant, and Wintergreen Plus were applied in Oct. 2013 in Manhattan, KS, and Haysville, KS, in solutions with water at 80, 160, or 240 gal/acre at a 1:6 dilution (colorant:water) and evaluated through late 2013 and Spring 2014. Tall fescue (*Festuca arundinacea*), a cool-season turfgrass commonly used in home lawns in the transition zone, was included for comparison. Persistence of green color increased with application volume, but differences among colorants were limited. Colorants provided acceptable color (i.e., a visual rating ≥6 on a 1 to 9 scale) for 55 to 69 days at 80 gal/acre, 69 to 118 days at 160 gal/acre, and 118 to 167 days at 240 gal/acre. Compared with tall fescue, colorant-treated zoysiagrass had significantly higher color ratings for 98 to 112 days at 80 gal/acre, 112 to 154 days at 160 gal/acre, and 138 to 154 days at 240 gal/acre. Colorants increased turfgrass canopy temperature by up to 12.1 °F, but did not accelerate spring green-up. Duration of acceptable color on 'Chisholm' zoysiagrass lawns can be enhanced by increasing colorant application volume.

Water is a limited resource and its use to irrigate landscapes is under increasing scrutiny. Warm-season turfgrasses, including zoysiagrass, are more heat and drought resistant than cool-season grasses, which results in water savings (Fry and Huang, 2004). In the transition zone, where both cool- and warm-season grasses are options, zoysiagrass requires fewer inputs of pesticides and fertilizers than most cool-season turfgrass species (Fry et al., 2008). However, in the transition zone, one perceived benefit of cool-season turfgrasses is that they remain green late into autumn and also green-up early in the spring. In contrast, zoysiagrass turns brown following the first autumn frost and remains dormant until mid to late spring. Some homeowners in the transition zone may avoid use of zoysiagrass because they object to its long duration of brown color during dormancy.

'Chisholm' zoysiagrass is a suitable turfgrass for residential and commercial lawns, parks, and golf courses in the transition zone (Chandra et al., 2014). In Kansas, 'Chisholm' usually takes on a straw-brown color of dormancy in October and begins to green-up in mid to late April as noted in studies during its development when it was evaluated under the experimental designation DALZ0102 (Okeyo et al., 2011). The dormancy period can be unappealing to homeowners, especially when cool-season grasses, which retain color longer in autumn and green-up sooner in spring, are grown in the same vicinity.

Turf colorants are an option for improving zoysiagrass color during dormancy. The use of turf colorants has become popular on golf course fairways and putting greens in the southern United States to provide green color during winter dormancy (Long, 2006). The turf colorants Titan Green Turf (Burnett Athletics, Campobello, SC), Green Lawnger (BASF Corp., Florham Park, NJ), and Regreen (Precision Laboratories, Waukegan, IL) provided acceptable turf quality on a 'TifEagle' hybrid bermudagrass (*Cynodon dactylon* × *C. transvaalensis*) putting green during the winter in South Carolina when applied in a dilution of 1:10 (colorant: water) at a rate of 283 gal/acre (Liu et al., 2007). The turf colorants Wintergreen Plus (Precision Laboratories) and Turf in a Bottle (US Specialty Coatings, Norcross, GA) applied once in autumn in a dilution of 1:10 (colorant: water) at rate of 80 gal/acre enhanced winter color of 'Diamond' zoysiagrass (*Zoysia matrella*) and 'Miniverde' hybrid bermudagrass putting greens (Briscoe et al., 2010).

Colorant application volume has been shown to affect turf color and duration. In North Carolina, intensity of visual turf color increased from 1% to 44% on 'Miniverde' hybrid bermudagrass and 11% to 15% on 'Diamond' zoysiagrass putting greens when application volumes increased from 80 to 160 gal/acre (Briscoe et al., 2010). Briscoe et al. (2010) reported a variety of turf colorants provided acceptable visual turf color up to at least 56 d after treatment at a rate of 80 gal/acre in 1:7 or 1:10 (colorant:water) dilutions on zoysiagrass mowed at golf course green height. It was also reported that there was an unspecified increase in the longevity of acceptable visual turf color for treated zoysiagrass greens with colorants Green

We appreciate the funding provided by the Heart of America Golf Course Superintendents Association, Kansas Golf Course Superintendents Association, and Kansas Turfgrass Foundation in support of this project.

We thanks Tim Todd, consulting statistician, for his assistance with data analysis. Colorant information and assistance provided by Grady Miller, Don Spier, and Jennifer Seevers were greatly appreciated. Contribution number 15-420-J of the Kansas Agricultural Experiment Station.

[1]Department of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS 66506

[2]Department of Plant Pathology, Kansas State University, Manhattan, KS 66506

[3]Corresponding author. E-mail: rossbraun@ksu.edu.

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.3048	ft	m	3.2808
3.7854	gal	L	0.2642
9.3540	gal/acre	L·ha^{-1}	0.1069
2.54	inch(es)	cm	0.3937
48.8243	lb/1000 ft^2	kg·ha^{-1}	0.0205
1.6093	mph	km·h^{-1}	0.6214
(°F – 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32

Lawnger, Turf in a Bottle, and Ultradwarf Super (Pioneer Athletics, Cleveland, OH) applied at a rate of 160 gal/acre (Briscoe et al., 2010). However, information is lacking on effects of colorants and application volumes on zoysiagrass maintained at the higher mowing heights used on home lawns and golf course roughs. Therefore, our objective was to quantify the impact of colorants applied in autumn at three application volumes on persistence of green color on lawn-height 'Chisholm' zoysiagrass.

Materials and methods

Study sites and treatments. Experiments were conducted at the Rocky Ford Turfgrass Research Center in Manhattan, KS, and the John C. Pair Horticultural Center in Haysville, KS. Turf was 'Chisholm' zoysiagrass maintained at a 2.5-inch height. No mowing occurred on zoysiagrass during the study due to winter dormancy. Soil at Manhattan was a Chase silt loam; at Haysville, soil was a Canadian-Waldeck fine sandy loam. Zoysiagrass at both locations received a June application 1 lb/1000 ft^2 nitrogen from urea (46N–0P–0K).

Plots measuring 5 × 8 ft were arranged in a randomized complete block design with three replicates. Treatments were 1) untreated, 2) Green Lawnger applied at a spray volume of 80 gal/acre, 3) Endurant (Geoponics Corp, Naples, FL) applied at 80 gal/acre, 4) Wintergreen Plus applied at 80 gal/acre, 5) Green Lawnger applied at 160 gal/acre, 6) Endurant applied at 160 gal/acre, 7) Wintergreen Plus applied at 160 gal/acre, 8) Green Lawnger applied at 240 gal/acre, 9) Endurant applied at 240 gal/acre, 10) Wintergreen Plus applied at 240 gal/acre, and 11) an established blend of tall fescue. Plots of tall fescue equivalent in size to those used to evaluate colorants were randomly assigned in three replicates in an area adjacent to the 'Chisholm' study area.

Colorants were applied using a one-nozzle, 3-gal rechargeable electric backpack sprayer (ProPack™ model SRS 600; SHURflo, Cypress, CA) with an adjustable cone nozzle calibrated to deliver 0.29 gal/min. Turf colorants were applied at a dilution of 1:6 (colorant:water) to 'Chisholm' zoysiagrass with 15% to 20% green turf color remaining based on visual evaluation on 11 Oct. 2013 at Manhattan and on 24 Oct. 2013 with 10% to 15% green turf color remaining at Haysville. Wind speeds during application were 3 to 8 mph at Manhattan and 10 to 15 mph at Haysville. Tall fescue was an unknown blend of turf-type cultivars that was not treated with colorants.

Data collection and analysis. Visual turf color was rated every other week at Manhattan and monthly from 24 Oct. to 8 Apr. thereafter every other week at Haysville on a 1 to 9 scale where 1 = straw brown, 6 = acceptable green color for a home lawn, and 9 = dark green (Morris and Shearman, 1999). For purposes of presentation, average monthly color ratings from 10 of 15 rating dates at Manhattan (Table 1) and 9 of 10 rating dates at Haysville (Table 2) are presented. Pantone color chips (Pantone LLC, 2015) were assigned 1 d after the first application for the 240-gal/acre rate of each colorant.

Number of days of acceptable color for each treatment was determined using visual ratings and regression analysis. The rating date when visual color first dropped below a score of 6 was recorded and days since application determined. To determine days of acceptable turf color for each application volume nested within colorant, a linear regression equation was derived for turf visual color vs. time using REG procedure in SAS (version 9.2; SAS Institute, Cary, NC). Subsequently, a visual color score of 5.9 (y value) was inserted into the equation to determine the days (x) that passed before that value was reached.

Starting 11 Mar. 2014, then every other week, soil temperatures at both sites at a 2-inch depth were measured and averaged from three measurements within each plot between 1300 and 1500 HR on cloudless days using a digital T-bar thermometer (Argus Realcold, Coopers Plains, Australia). On the same date (11 Mar.), canopy temperatures at both sites were measured, and averaged, from three locations per plot between 1300 and 1500 HR on cloudless days using a handheld infrared thermometer at a 4-ft height above the canopy (model 100.3ZL; Everest Interscience, Tucson, AZ). Spring green-up of zoysiagrass was measured by visually inspecting new turf growth extending above the turf canopy, along with turf color ratings by investigators during late April/May rating dates.

Residual normality was tested with the w statistic of the Shapiro–Wilk test using the UNIVARIATE procedure of SAS (version 9.2) (Shapiro and Wilk, 1965). Data were subjected to a 2-fold nested analysis of variance using the GLIMMIX procedure of SAS 9.2 due to the fact of three application volumes nested within each colorant and only one "application volume" of tall fescue and untreated zoysiagrass was included. Factors were application volume nested within colorant and colorant. Treatment differences were separated using Fisher's protected least significant difference test ($P \leq 0.05$). A homogeneity of variance test for location by treatment effect was significant for the study sites; therefore, results will be presented separately for each site. Data were also subjected to linear regression using the REG procedure in SAS (version 9.2).

Results and discussion

Turf color. Color of 'Chisholm' zoysiagrass after application of Green Lawnger and Endurant was dark green, whereas that treated with Wintergreen Plus was blue green (Fig. 1). Pantone Color chips 357 C for Green Lawnger, 2266 C for Endurant, and 3295 C for Wintergreen Plus were assigned as the representative Pantone matching system for each colorant applied at a rate of 240 gal/acre on lawn-height 'Chisholm' zoysiagrass at 1 d; lower application volumes resulted in a less intense, brighter representative color (Pantone LLC, 2015). Some turf managers may prefer one color to another, but our color ratings reflected the intensity of the color, and we did not consider the hue of green in visual ratings.

The effect of spray volume nested within colorants was significant; therefore, each spray volume within each colorant was evaluated across all 11 treatments (Tables 1 and 2). Representative examples of change in visual appearance of colorant-treated 'Chisholm' are shown in Fig. 1 (1 d) and Fig. 2 (118 d). In general, duration of acceptable turf color at each location increased with increasing application volume, and color ratings at each application volume decreased over time (Tables 1–3). All colorant-treated zoysiagrass had superior color compared with untreated zoysiagrass for a total of 197 d in Manhattan [11 Oct. to 25 Apr. (Table 1)] and 141 to 181 d in

Table 1. Effect of colorant and application volume on color of 'Chisholm' zoysiagrass at the Rocky Ford Turfgrass Research Center, Manhattan, KS, in 2013–14.

	Turf color (1–9 scale)[y]									
	11 Oct.	6 Nov.	6 Dec.	18 Dec.	15 Jan.	25 Jan.	24 Feb.	26 Mar.	9 Apr.	25 Apr.
	Time after colorant treatment (d)									
Treatment (gal/acre)[z]	1	27	57	69	97	107	137	167	181	197
Green Lawnger										
80	8.7 ab[x]	7.3 de	7.0 de	6.7 cd	5.3 cd	5.0 d	4.3 e	3.7 de	3.0 ef	3.0 cd
160	9.0 a	8.3 abc	8.3 abc	7.0 bc	5.3 cd	4.7 d	4.7 de	3.7 de	3.3 def	3.3 cd
240	9.0 a	9.0 a	9.0 a	8.0 a	7.7 a	7.0 ab	7.0 a	6.0 a	5.7 ab	5.0 b
Endurant										
80	8.0 c	7.0 ef	6.3 ef	6.0 d	5.0 d	4.3 d	4.3 e	3.3 e	3.3 def	3.0 cd
160	8.3 bc	8.0 bcd	8.0 bc	7.7 ab	6.0 bc	6.0 c	5.7 bc	4.3 cd	4.3 cd	3.7 c
240	9.0 a	8.7 ab	8.7 ab	8.3 a	6.3 b	6.3 bc	6.0 bc	5.3 ab	5.0 bc	5.0 b
Wintergreen Plus										
80	7.3 d	6.3 f	6.0 fg	6.0 d	4.7 d	4.7 d	3.0 f	3.0 e	2.3 f	2.3 d
160	8.7 ab	8.0 bcd	7.7 cd	7.7 ab	6.3 b	6.0 c	5.3 cd	5.0 bc	4.0 cde	4.0 bc
240	9.0 a	8.7 ab	8.0 bc	7.7 ab	7.7 a	7.7 a	6.3 ab	4.7 bc	4.0 cde	4.0 bc
Tall fescue	9.0 a	7.7 cde	5.5 g	2.0 e	1.0 e	1.0 e	1.0 g	3.0 e	6.7 a	8.7 a
Untreated	3.0 e	1.0 g	1.0 h	1.0 f	1.0 e	1.0 e	1.0 g	1.0 f	1.0 g	1.0 e

[z]Green Lawnger, Endurant, and Wintergreen Plus were applied on 11 Oct. 2013 at a dilution of 1:6 (colorant:water) using a one-nozzle, 3-gal (11.4 L) rechargeable electric backpack sprayer with an adjustable cone nozzle calibrated to deliver 0.29 gal (1.098 L) per minute; 1 gal/acre = 9.3540 L·ha^{-1}.
[y]Turf color was rated visually on a 1 to 9 scale where 1 = straw brown, 6 = acceptable green color (light green), and 9 = dark green.
[x]Means in a column followed by the same letter are not significantly different according Fisher's protected least significant difference test ($P \leq 0.05$).

Table 2. Effect of colorant and application volume on color of 'Chisholm' zoysiagrass at the John C. Pair Horticultural Center, Haysville, KS, in 2013–14.

	Turf color (1–9 scale)[y]								
	24 Oct.	21 Nov.	17 Dec.	17 Jan.	18 Feb.	13 Mar.	8 Apr.	22 Apr.	6 May
	Time after colorant treatment (d)								
Treatment (gal/acre)[z]	1	29	55	86	118	141	167	181	195
Green Lawnger									
80	6.7 cd[x]	6.7 ef	6.7 c	3.7 de	3.0 cd	3.0 ef	2.3 def	2.7 e	4.7
160	8.0 b	8.0 bc	8.0 ab	6.3 bc	4.7 b	4.0 cde	3.7 cd	4.3 cd	5.3
240	9.0 a	9.0 a	8.7 a	7.3 ab	6.3 a	6.0 ab	5.7 ab	5.7 b	6.0
Endurant									
80	6.3 d	6.3 f	6.0 c	3.3 e	2.7 d	2.3 f	2.0 ef	2.3 e	4.0
160	7.7 b	7.3 cde	7.0 bc	6.0 c	4.7 b	3.7 de	3.0 cde	3.3 de	4.7
240	9.0 a	9.0 a	8.7 a	6.7 bc	6.0 a	4.7 cd	4.3 bc	4.3 cd	4.7
Wintergreen Plus									
80	7.0 c	7.0 def	6.3 c	4.7 d	3.7 c	3.3 ef	2.7 de	2.3 e	5.0
160	9.0 a	8.7 ab	8.3 a	6.7 bc	6.0 a	5.0 bc	4.3 bc	4.0 cd	5.3
240	9.0 a	9.0 a	9.0 a	8.0 a	6.7 a	6.3 a	5.7 ab	4.7 bc	5.7
Tall fescue	9.0 a	7.7 cd	3.3 d	1.0 f	1.0 e	1.0 g	6.7 a	8.3 a	9.0
Untreated	1.0 e	1.0 g	1.0 e	1.0 f	1.0 e	1.0 g	1.0 f	1.0 f	2.3

[z]Green Lawnger, Endurant, and Wintergreen Plus were applied on 24 Oct. 2013 at a dilution of 1:6 (colorant:water) using a one nozzle, 3-gal (11.4 L) rechargeable electric backpack sprayer with an adjustable cone nozzle calibrated to deliver 0.29 gal (1.098 L) per minute; 1 gal/acre = 9.3540 L·ha^{-1}.
[y]Turf color was rated visually on a 1 to 9 scale where 1 = straw brown, 6 = acceptable green color (light green), and 9 = dark green.
[x]Means in a column followed by the same letter are not significantly different according Fisher's protected least significant difference test ($P \leq 0.05$). Lack of letters indicates no significant differences ($P > 0.05$) on that date.

Haysville [24 Oct. to 13 Mar./22 Apr. (Table 2)].

Differences in color ratings based on the application volumes of 160 vs. 80 gal/acre for all three colorant products were evident at Manhattan at 27 d and at Haysville at 29 d after treatment (Tables 1 and 2). Across all three colorant products at 27 and 29 d, turf color was 14% to 27% higher in turf treated at 160 compared with 80 gal/acre, 3% to 23% higher in turf treated at 240 compared with 160 gal/acre, and 23% to 43% higher in turf treated at 240 compared with 80 gal/acre. The same volume-dependent effect on color occurred throughout the experiments in Manhattan and Haysville. The enhanced color on 'Chisholm' zoysiagrass that we observed with increasing colorant application volume was similar to the findings of Briscoe et al. (2010) who evaluated increasing colorant application volume on 'Diamond' zoysiagrass putting greens in North Carolina. In that experiment, turf color 35 d after treatment was 11% to 15% greater when the colorants Green Lawnger, Turf in a Bottle, and Ultradwarf Super were applied at 160 compared with 80 gal/acre (Briscoe et al., 2010).

Fig. 1. 'Chisholm' zoysiagrass experimental area at the Rocky Ford Turfgrass Research Center, Manhattan, KS, on 11 Oct. 2013 (1 d): (A) Green Lawnger at 160 gal/acre, (B) untreated, (C) Endurant at 240 gal/acre, (D) Wintergreen Plus at 240 gal/acre, (E) Wintergreen Plus at 80 gal/acre, (F) Wintergreen Plus at 160 gal/acre, (G) Endurant at 160 gal/acre, (H) Endurant at 80 gal/acre, (I) Green Lawnger at 80 gal/acre, and (J) Green Lawnger at 240 gal/acre; 1 gal/acre = 9.3540 L·ha^{-1}.

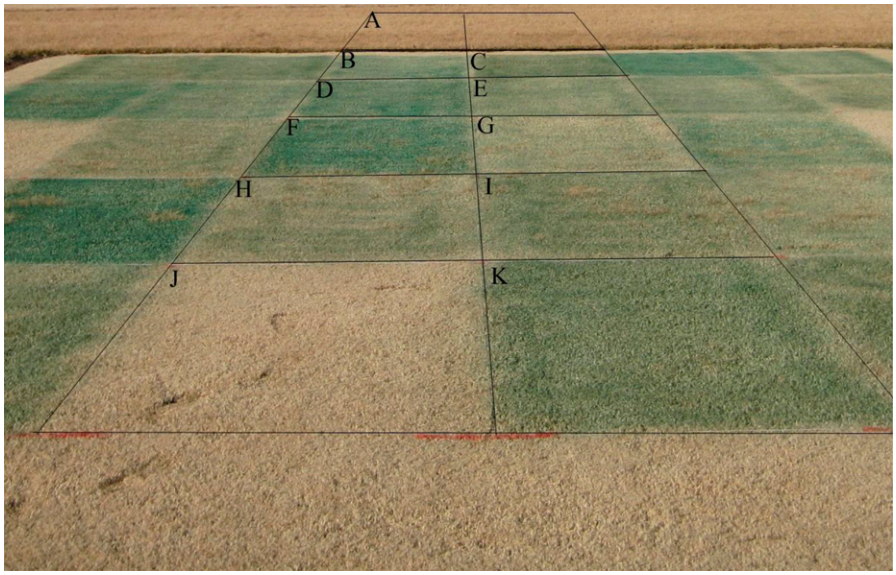

Fig. 2. Chisholm zoysiagrass experimental area on 18 Feb. 2014 (118 d) at the John C. Pair Horticultural Center, Haysville, KS: (A) 'K-31' tall fescue, (B) Wintergreen Plus at 80 gal/acre, (C) Green Lawnger at 240 gal/acre, (D) Wintergreen Plus at 160 gal/acre, (E) Endurant at 160 gal/acre, (F) Wintergreen Plus at 240 gal/acre, (G) Endurant at 80 gal/acre, (H) Green Lawnger at 80 gal/acre, (I) Green Lawnger at 160 gal/acre, (J) untreated, and (K) Endurant at 240 gal/acre. Tall fescue in this image is a representative depiction of the tall fescue plot area that lay adjacent to the colorant study area; 1 gal/acre = 9.3540 L·ha^{-1}.

Tall fescue, a commonly used cool-season grass in Kansas, had better visual turf color than untreated 'Chisholm' zoysiagrass for a total of 112 d between 11 Oct. and 21 May (a 223-d period) in Manhattan and 83 d between 24 Oct. and 20 May (a 209-d period) in Haysville (Tables 1 and 2). However, tall fescue had a below-acceptable color rating for 124 d in Manhattan and 112 d in Haysville. Considering both locations, colorants applied at 80 gal/acre enhanced color compared with tall fescue for 98 d (Wintergreen Plus in Manhattan), 110 d (Green Lawnger and Endurant in Manhattan), and 112 d (Green Lawnger, Endurant, and Wintergreen Plus in Haysville). Colorants applied at 160 gal/acre provided zoysiagrass with better color than tall fescue for 112 d (Green Lawnger and Endurant in Haysville), 138 d (Wintergreen Plus in Haysville), 140 d (Green Lawnger in Manhattan), and 154 d (Endurant and Wintergreen Plus in Manhattan). All three colorant products applied at 240 gal/acre provided turf with significantly better color than tall fescue for 154 d in Manhattan and 138 d in Haysville.

Colorants provided definitive differences in color intensity and duration of color for 80 vs. 240 gal/acre, but differences between 160 vs. 240 gal/acre and 80 vs. 160 gal/acre were generally less pronounced (Tables 1 and 2). Based on observed visual ratings across all colorants and locations, 'Chisholm' color was acceptable for an average of 62 d at 80 gal/acre, 96 d at 160 gal/acre, and 140 d at 240 gal/acre (Table 3). Predicted days of acceptable color determined using regression analysis generally mirrored those of visual ratings, with R^2 values ranging from 0.72 to 0.93.

Both sites had a similar duration of zoysiagrass dormancy, however, there was less green zoysiagrass color remaining and a greater wind speed during colorant application at Haysville, which may have affected color intensity and duration compared with Manhattan. A higher amount of green turf color remaining and proper environmental conditions duration application could possibly influence color intensity and duration. Zoysiagrass dormancy periods vary by region and by variations in annual weather, and locations with shorter periods of dormancy

may be able to maintain a sufficient duration of acceptable color with a lower application rate, such as 80 gal/acre. Multiple applications at lower rates are also an option and were evaluated by Braun (2014), but those results were not presented herein.

TEMPERATURE. Colorants influenced canopy (Table 4) but not soil (data not shown) temperatures. Neither the effect of application volume nested within colorant nor the main effect of colorant was significant for soil temperature at either site. The main effect of colorant was significant at both experiment locations; however, application volume nested within colorant effect was not significant for canopy temperature at either site. Turf treated with any of the colorants had higher canopy temperatures on at least one date at each location (Table 4). In Manhattan, turf colorants applied to zoysiagrass increased canopy temperatures across rating dates an average of 5.8 °F, and the largest canopy temperature difference (12.1 °F) occurred between Endurant-treated and untreated zoysiagrass on 26 Mar. 2014. In Haysville, colorants increased canopy temperatures across rating dates an average of 5 °F with the largest canopy temperature difference (7.3 °F) occurring between Green Lawnger-treated and untreated zoysiagrass on 8 Apr. 2014. The darker color of treated plots likely contributed to their higher canopy temperatures by absorbing more shortwave radiation than untreated plots. However, the high mowing height and dense canopy of the 'Chisholm' in all plots may have shaded the soil to the extent it prevented a colorant influence on soil temperatures. Through visual inspection of the turf canopy on multiple rating dates, the differences in canopy temperatures did not stimulate earlier green-up of colorant-treated vs. untreated zoysiagrass.

Colorants applied to 'TifEagle' and 'Champion' hybrid bermudagrass putting greens in Chandler, AZ, and Paradise Valley, AZ, respectively, increased canopy temperatures up to 10.2 °F in January (Whitlark, 2012; Whitlark and Umeda, 2012). Buffalograss (*Buchloe dactyloides*) treated in December with Lesco Green (John Deere Landscapes, Alpharetta, GA) had soil temperatures up to 8.4 °F higher at 2-inch depth, which resulted in spring green-up in turf color 14 d earlier than untreated turf in Nebraska (Shearman et al., 2005).

Table 3. Days of acceptable green color of 'Chisholm' zoysiagrass based upon visual color ratings (observed) and regression analysis (predicted) at the Rocky Ford Turfgrass Research Center, Manhattan, KS, and John C. Pair Horticultural Center, Haysville, KS, in 2013–14.

		Duration of acceptable green color (d)		
Treatment (gal/acre)[z]	Location[y]	Observed[x]	Predicted[w]	R^{2v}
Green Lawnger				
80	M	69	80	0.87
	H	55	40	0.80
160	M	69	99	0.89
	H	86	93	0.72
240	M	167	167	0.93
	H	141	152	0.82
Endurant				
80	M	69	65	0.91
	H	55	28	0.79
160	M	107	116	0.86
	H	86	74	0.90
240	M	137	141	0.90
	H	118	117	0.92
Wintergreen Plus				
80	M	69	50	0.91
	H	55	50	0.92
160	M	107	115	0.93
	H	118	114	0.87
240	M	137	132	0.86
	H	141	150	0.86

[z]Turf color was rated visually on a 1 to 9 scale where 1 = straw brown, 6 = acceptable green color (light green), and 9 = dark green. Green Lawnger, Endurant, and Wintergreen Plus were applied on 11 Oct. 2013 at a dilution of 1:6 (colorant:water) using a one nozzle, 3-gal (11.4 L) rechargeable electric backpack sprayer with an adjustable cone nozzle calibrated to deliver 0.29 gal (1.098 L) per minute; 1 gal/acre = 9.3540 L·ha^{-1}.
[y]M = Rocky Ford Turfgrass Research Center, Manhattan, KS; H = John C. Pair Horticultural Center, Haysville, KS.
[x]Observed number of days after application for colorant treatment to drop below acceptable color based on visual ratings.
[w]Predicted number of days after application for colorant treatment to drop below acceptable color based on regression analysis.
[v]Coefficient of determination for the regression analysis.

Table 4. Effect of colorant on canopy temperature of 'Chisholm' zoysiagrass at the Rocky Ford Turfgrass Research Center, Manhattan, KS, and the John C. Pair Horticultural Center, Haysville, KS, in 2014.

	Canopy temp (°F)[y]								
	Manhattan, KS					Haysville, KS			
Treatment[z]	11 Mar.	26 Mar.	11 Apr.	25 Apr.	9 May	13 Mar.	8 Apr.	22 Apr.	6 May
Green Lawnger	73.4 a[x]	83.5 b	100.4 a	94.5 ab	104.0 b	69.8 a	71.5 a	92.1	92.6
Endurant	73.8 a	88.0 a	101.8 a	95.9 a	107.9 a	69.6 a	69.3 ab	92.0	93.5
Wintergreen Plus	72.2 b	82.6 b	97.6 b	92.7 bc	100.5 c	67.6 b	69.1 ab	90.7	92.5
Untreated	69.3 c	75.9 c	93.2 c	90.9 c	97.8 c	64.9 c	64.2 b	86.2	88.1

[z]Green Lawnger, Endurant, and Wintergreen Plus were applied on 11 Oct. 2013 in Manhattan, KS, and 24 Oct. 2013 in Haysville, KS, at a dilution of 1:6 (colorant:water) using a one-nozzle, 3-gal (11.4 L) rechargeable electric backpack sprayer with an adjustable cone nozzle calibrated to deliver 0.29 gal (1.098 L) per minute.
[y]Canopy temperature was measured and averaged from three measurements within each plot using a handheld infrared thermometer; (°F – 32) ÷ 1.8 = °C.
[x]Means in a column followed by the same letter are not significantly different according Fisher's protected least significant difference test ($P \leq 0.05$). Lack of letters indicates no significant differences ($P > 0.05$) on that date.

In summary, Endurant, Green Lawnger, and Wintergreen Plus provided longer lasting acceptable visual color on 'Chisholm' zoysiagrass as volume increased from 80 to 240 gal/acre, averaging 62 d at 80 gal/acre, 96 d at 160 gal/acre, and 140 d at 240 gal/acre. Some homeowners may be more amenable to the use of 'Chisholm', or other warm-season turfgrasses, if colorants are used to enhance the aesthetic appeal of dormant turf.

Literature cited

Braun, R. 2014. Cultural strategies to improve zoysiagrass acceptability and performance in the transition zone. MS Thesis, Kansas State Univ., Manhattan, NY.

Briscoe, K., G. Miller, and S. Brinton. 2010. Evaluation of green turf colorants as an alternative to overseeding on putting greens. Appl. Turfgrass Sci. doi:10.1094/ATS-2010-0326-02-RS.

Chandra, A., J. Fry, M. Engelke, D. Genovesi, J. Reinert, M. Binzel, S. Metz, B. Wherley, Q. Zhang, and D. Okeyo. 2014. Registration of 'Chisholm' zoysiagrass. J. Plant Registrations 9:21–26.

Fry, J. and B. Huang. 2004. Applied turfgrass science and physiology. Wiley, Hoboken, NJ.

Fry, J., M. Kennelly, and R. St. John. 2008. Zoysiagrass: Economic and environmental sense in the transition zone. Golf Course Mgt. 76(5):127–132.

Liu, H., B.L. McCarty, C.M. Baldwin, W.G. Sarvis, and S.H. Long. 2007. Painting dormant bermudagrass putting greens. Golf Course Mgt. 75(11):86–91.

Long, S.H. 2006. Thatch control, winter painting, and plant regulator management on golf course putting greens. MS Thesis, Clemson Univ., Clemson, SC.

Morris, K.N. and R.C. Shearman. 1999. NTEP turfgrass evaluation guidelines. Natl. Turfgrass Evaluation Program, Beltsville, MD.

Okeyo, D.O., J.D. Fry, D. Bremer, C.B. Rajashekar, M. Kennelly, A. Chandra, D.A. Genovesi, and M.C. Engelke. 2011. Freezing tolerance and seasonal color of experimental zoysiagrass. Crop Sci. 51:2858–2863.

Pantone, LLC. 2015. Find a Pantone color. 1 Dec. 2015. <http://www.pantone.com/pages/pantone/colorfinder.aspx?mm>.

Shapiro, S.S. and M.B. Wilk. 1965. An analysis of variance test for normality (complete samples). Biometrika 52:591–611.

Shearman, R.C., L.A. Wit, S. Severmutlu, H. Budak, and R.E. Gaussoin. 2005. Colorant effects on dormant buffalograss turf performance. HortTechnology 15:244–246.

Whitlark, B. 2012. Ultradwarf bermudagrass tinting study: How do different paints and pigments affect the surface temperature of greens? USGA Green Section Record 50(3):1–6.

Whitlark, B. and K. Umeda. 2012. A New Hue: A guide to using colorants to enhance the color and growth of fine turfgrass in the southwestern U.S. USGA Green Section Record 50(20):1–2.