



Turfgrass and Environmental Research Online

...Using Science to Benefit Golf



USGA's Turfgrass and Environmental Research Program jointly funded a cooperative study with GCSAA's Environmental Institute for Golf to evaluate commonly used wetting agents on golf courses. Nine sites across the US were chosen and data were taken for phytotoxicity, turf color, turf quality, and degree of soil hydrophobicity. For the sake of regular readers of *TERO*, and with permission from GCSAA, the report presented in this issue of *TERO* is exactly how it appeared in the April and August issues of *Golf Course Management*, GCSAA's flagship publication.

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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of \$25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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This research was funded by The Environmental Institute for Golf and USGA.

GCSAA-USGA wetting agent evaluation: Update

A reanalysis of the water-droplet-penetration-test data shows no biologically significant changes from the original results.

Clark Throssell, Ph.D.

In the April 2005 edition of *Golf Course Management*, GCSAA released the results of the GCSAA-USGA Wetting Agent Evaluation. Further examination of the results after publication revealed an error in the analysis of the water-droplet-penetration-test data for the nine sites for both 2003 and 2004.

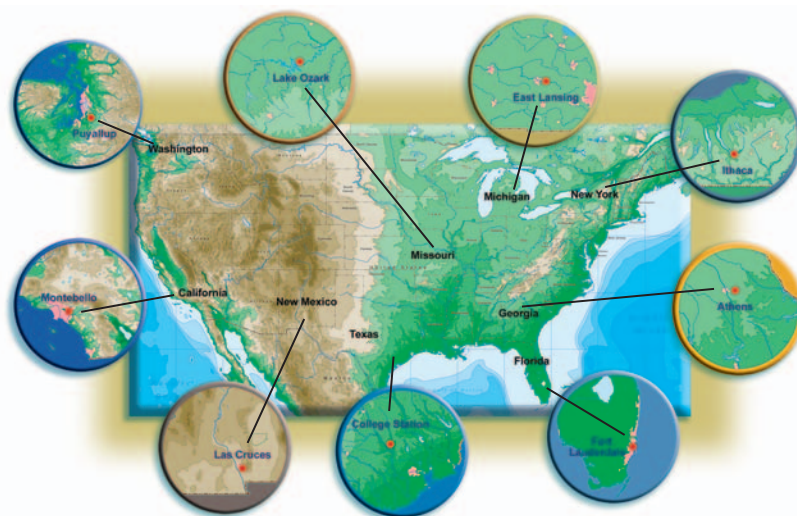
Water-droplet-penetration-test data were collected on six separate dates each year at specified intervals throughout the course of the evaluation. To determine the uniformity of the research plots, the first date of data collection occurred before any wetting agents were applied. The other five collection dates occurred after the wetting agents had been applied.

In the original analysis of the water-droplet-penetration-test data, data from all six dates were included in the analysis. This was incorrect. Only the water-droplet-penetration-test data collected from the five dates after the application of wetting agents should have been included in the analysis.

Statisticians from the National Turfgrass Evaluation Program (NTEP) have reanalyzed the water-droplet-penetration-test data using only the data collected from the five dates after wetting agents had been applied. The results of the reanalysis of the water-droplet-penetration-test data for all nine sites for both 2003 and 2004 are presented in the following pages.

The reanalysis of the water-droplet-penetration-test data revealed five major points.

- The research plots within each of the nine evaluation sites were uniform in their degree of soil hydrophobicity before wetting agents were applied. This uniformity is desirable because it means that all the



The nine sites for the wetting agent evaluation were distributed across the United States.

plots within each site were in similar condition at the start of the experiment.

- Because the plots at each evaluation site were uniform before the wetting agents were applied, the results of the two data analyses were similar. That is, the reanalysis of the water-droplet-penetration-test data using only data collected after wetting agents were applied showed only minor differences from the results of the original data analysis.
- The relative performance of the wetting agents in reducing water-droplet-penetration time at each site is nearly unchanged following the reanalysis of the data. A wetting agent that was effective in reducing water-droplet-penetration time as reported in the April issue was still effective in reducing water-droplet-penetration time when the data were reanalyzed.
- The relationship among wetting agents for

their ability to reduce water-droplet-penetration time at each site is unchanged or changed only slightly.

- The water-droplet-penetration times reported for each site have changed somewhat because the data collected before application of the wetting agents was excluded from the reanalysis. The changes in the water-droplet-penetration time have little impact on the interpretation of the results.

Although the results may have changed little following the reanalysis of the water-droplet-penetration-test data, it is only fair to all involved to ensure that the data are analyzed correctly and the correct results are published.

Clark Throssell is GCSAA's director of research.



This research was funded by The Environmental Institute for Golf and USGA.

GCSAA-USGA wetting agent evaluation

Superintendents can now reap the benefits of two years of comparative studies of wetting agents.

Clark Throssell, Ph.D.

GCSAA, through funding from The Environmental Institute for Golf and USGA, has completed an evaluation of selected wetting agents that began in spring 2003. For several years before the study was initiated, superintendents had expressed a strong desire for product comparison data to help them make informed product use and purchasing decisions. In response, the GCSAA research committee developed the concept of a program coordinated by GCSAA to evaluate products that are commonly used by superintendents but currently receive limited evaluation in university trials. The committee recommended, and the GCSAA Board of Directors approved, the evaluation of wetting agents for the pilot program. Wetting agents were chosen because they are widely used by superintendents across the country to manage localized dry spots, an important problem on greens, and because comparison of wetting agents in side-by-side university trials has been limited.

After the results from the evaluation have been made available, feedback will be sought from golf course superintendents, wetting agent manufacturers and the university scientists who conducted the research to help determine the value of the pilot program. Ultimately, the association will decide whether to continue the program and evaluate other products.

Advisory panel

To help GCSAA conduct the best-

possible evaluation, a 10-member advisory panel was created to define experimental objectives, develop the scientific protocol, select evaluation sites, determine the method to use for including products in the evaluation and provide direction for disseminating the results. The panel comprised golf course superintendents Darren Davis, Mark Kienert, CGCS; Robert J. Maibusch, CGCS, MG; Brian Sullivan, CGCS, MG; and Mark Woodward, CGCS. Also on the panel were three university scientists who have conducted wetting agent research — John Cisar, Ph.D.; Keith Karnok, Ph.D.; and Robert Shearman, Ph.D. — and the directors of research for the USGA Green Section, Mike Kenna, Ph.D., and for GCSAA, Clark Throssell, Ph.D.

Objectives

Superintendents use wetting agents to address many different problems on the golf course, but limitations in time and funding required the scope of the evaluation to be very specific. The advisory panel decided the overall objective of the evaluation was to determine the effectiveness of selected wetting agents for managing localized dry spots on putting greens. Specific objectives were to determine:

- phytotoxicity damage to turf following wetting agent applications
- the impact of wetting agent applications on turf color and quality
- the degree of soil hydrophobicity following wetting agent applications
- dew formation following wetting agent applications
- pest damage following wetting agent applications

Localized dry spots

Although localized dry spots on putting greens can have many causes, this evaluation focused on hydrophobic or water-repellent soils. An organic coating on the soil particles, which may originate from plants, microorganisms and decomposing organic matter, causes soil to become hydrophobic (1). Soil hydrophobicity is most severe in the upper 1-2 inches (2.5-5 centimeters) of the soil profile.

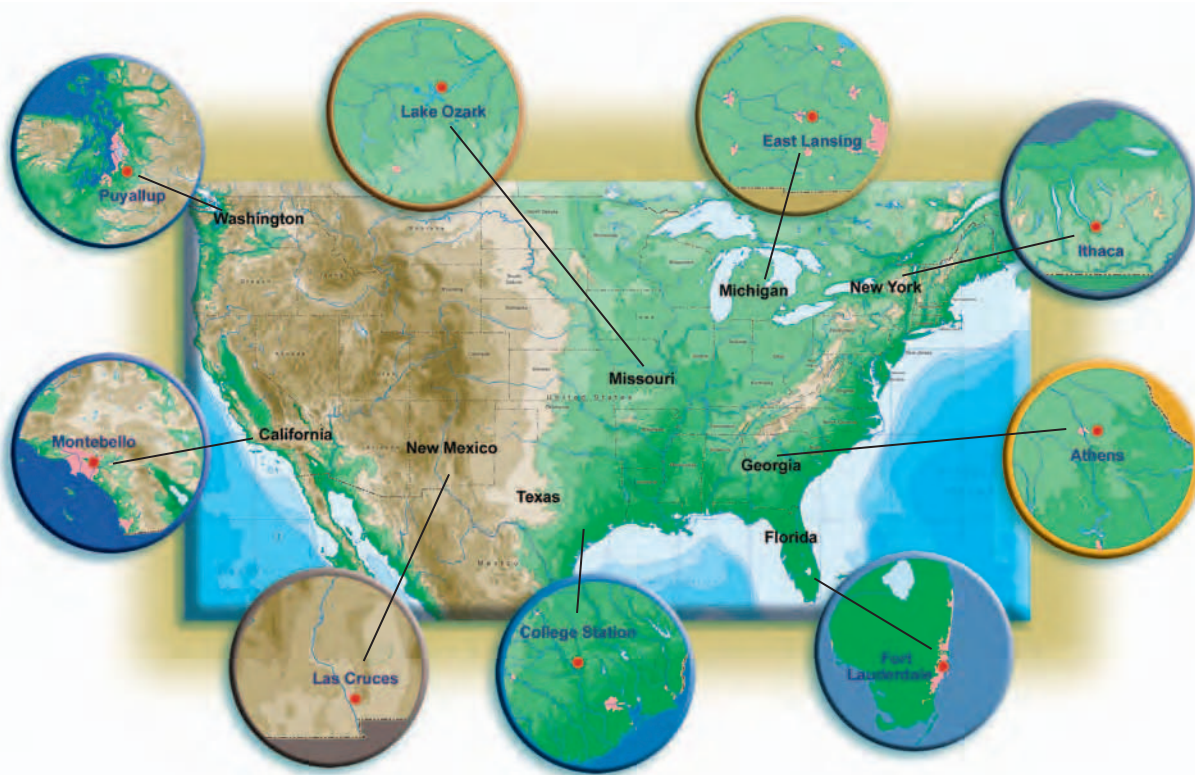
Symptoms of localized dry spots are roughly circular patches of tan-colored, drought-stressed turf 12 inches (30.5 centimeters) to several feet in diameter. Turf within the localized dry spots may thin out over time, and, in severe cases, portions of the turf may die. Localized dry spots are most severe during periods of extended high temperatures and dry weather (2).

Recommended treatments for managing localized dry spots caused by hydrophobic soil include cultivation of localized dry spots to increase water penetration, hand watering to increase soil moisture content, and preventive and/or curative application of wetting agents (2).

Materials and methods

Evaluation sites

The advisory panel determined that the evaluation should be conducted at nine sites around the country that represented broad geographic regions with diverse climates and growing conditions. Interested scientists were required to submit a site profile of the putting green that would be used to conduct the evaluation. Criteria for selecting sites



The nine sites for the wetting agent evaluation were distributed across the United States.

were geographic location, a high-sand-content root zone, a history of localized dry spots on the putting green and the degree of soil hydrophobicity as determined by the water-droplet-penetration test. Locations for the wetting agent evaluation are shown on the map (above).

Wetting agents

Because of funding constraints and limited usable research plot space that met the evaluation site criteria, the advisory panel determined that 10 wetting agents and an untreated control would be evaluated. The panel selected the top 10 wetting agents that were used by superintendents, as indicated in the 2002 Plant Protectant and Fertilizer Usage Study, and were commercially available in 2003.

All products were applied according to label directions and at the highest label rate for control/management of localized dry spots. A complete list of the wettings agents, rates and timing of applications is given in Table 1.

During the two years of the evaluation, the wetting agents were identified by code.

Scientists did not know the identity of the products until all data had been collected.

Duration of the evaluation

The wetting agent evaluation was conducted over a four-month period in 2003 and 2004 when stress from localized dry spots was at its peak. Each scientist determined when the peak stress period occurred from the presence of localized dry spots at the site.

Data collected

At each site, data were collected for phytotoxicity, turf color and quality and degree of soil hydrophobicity.

Phytotoxicity. Ratings were taken one, three and seven days after each application of a wetting agent. All plots were rated each time phytotoxicity ratings were taken. The rating scale is 1-9, where 1 = brown or discolored turf, 7 = acceptable damage and 9 = green turf, no damage.

Turf color. Ratings were taken every two weeks beginning seven days after the initial application of the first wetting agent treat-

ment. The rating scale is 1-9, where 1 = brown, 5 = medium green and 9 = dark green.

Turf quality. Ratings were taken every two weeks beginning seven days after initial application of the first wetting agent treatment. The rating scale is 1-9, where 1 = poor quality, 5 = acceptable quality and 9 = excellent quality.

Degree of soil hydrophobicity. The water-droplet-penetration test was used to determine soil hydrophobicity. Soil cores 1.9 centimeters (0.75 inch) in diameter were taken to a depth of 6 centimeters (2.4 inches). Droplets of distilled, deionized water were placed on soil cores at 0.5, 1.5, 2.5, 3.5, 4.5 and 5.5 centimeters (0.2, 0.6, 0.9, 1.4, 1.8 and 2.2 inches) below the soil surface. The time it took for the water droplet to penetrate into the soil core was determined. The maximum time for water-droplet penetration was 600 seconds. Any water droplet remaining after 600 seconds was recorded as 600 seconds. Three to five soil cores were taken per plot. Water-droplet-penetration times (WDPT) from all

WETTING AGENT STUDY

WETTING AGENTS AND RATES

Product/rate (ounces)*	Timing	Spray volume (gallons/1,000 sq. ft.)†	Watering in
Aqueduct			
8	first application	1	irrigate before next mowing
8	1 week after first application	1	irrigate before next mowing
8	once every four weeks after second application	1	irrigate before next mowing
Brilliance			
8	first application	2	immediately after application
8	10 days after first application	2	immediately after application
8	12 weeks after second application	2	immediately after application
Cascade Plus			
8	first application	2	immediately after application
8	10 days after first application	2	immediately after application
Hydro-Wet			
8	first application	10	immediately after application
8	two weeks after first application	10	immediately after application
2	every two weeks after second application	5	immediately after application
LescoFlo			
8	first application	10	immediately water in
8	two weeks after first application	10	immediately water in
Naiad			
8	first application	10	immediately after application
8	two weeks after first application	10	immediately after application
6	once every four weeks after second application	10	immediately after application
Primer Select			
6	first application	2	irrigate before next mowing
6	every four weeks following first application	2	irrigate before next mowing
Respond 2			
10	first application	8	immediately after application
10	8 weeks after first application	8	immediately after application
Surfside 37			
32	first application	10	immediately after application
4	every two weeks after first application	10	immediately after application
TriCure			
6	first application	2	immediately water in
6	every four weeks following first application	2	immediately water in

*2, 4, 6, 8, 10 and 32 ounces = 59.1 milliliters, 0.12 liter, 0.17 liter, 0.24 liter, 0.30 liter and 0.94 liter, respectively.

†1, 2, 5, 8, and 10 gallons/1,000 square feet = 40.7, 81.5, 203.7, 326 and 407.5 liters/1,000 square meters, respectively.

Table 1. Wetting agents, rates of application in fluid ounces, timing of application, spray volume and post-application watering instructions used in the GCSAA/USGA wetting agent evaluation. The first application of all wetting agents was made on the same date and before the appearance of any symptoms of localized dry spots.

WDPT SCALE

Time (seconds)	Degree of repellency
0 – 5	none
5 – 60	slight
60 – 600	moderate to high
600 – 3,600	severe
above 3,600	extreme

Table 2. Scale for interpreting water-droplet-penetration test data.

cores from each plot were averaged by depth, and that average was used to characterize that plot. Soil cores were collected for the water-droplet-penetration test within five days before the first wetting agent application and at two, four, eight, 12 and 16 weeks after the first wetting agent application.

The scale for interpreting water-droplet-penetration test data is shown in Table 2.

Additional data on dew and pest damage were collected at some sites. Data for these variables are available at www.eifg.org.

Experimental design

Minimum plot size was 3 by 3 feet (0.9 by 0.9 meter), and scientists were encouraged to use larger plots if sufficient uniform research area was available. Each treatment was replicated four times. The same plots used for the evaluation in 2003 were used in 2004, with the same treatments applied to the same plots in both years. Treatments were arranged in a randomized complete block design.

Data analysis

Guangling Gao, Ph.D., and Kevin Morris of the National Turfgrass Evaluation Program analyzed data from all sites. Analysis of variance and mean separation were performed to determine the impact of the wetting agents. All data were analyzed by NTEP to ensure uniformity. Data for each site were analyzed and reported separately. The data were not analyzed and summarized over all locations.

Research site management

The advisory panel required creeping

bentgrass greens in the evaluation to be mowed at a maximum height of 0.140 inch (3.6 millimeters) at least six days per week. For bermudagrass greens, the maximum mowing height was 0.156 inch (4 millimeters) and the minimum mowing frequency was six days per week. Cultivation that penetrated the soil surface was not allowed during the four-month evaluation period. Grooming and light verticutting were allowed, provided the blades did not penetrate the soil surface. Topdressing with 100% sand was allowed during the evaluation period.

Watering practices followed during the evaluation are broken down by week.

- *Weeks 1 through 8.* Plots were watered at 70% potential evapotranspiration (ET) for bermudagrass greens and 80% potential ET for creeping bentgrass greens. These crop coefficients were guidelines, and adjustments were permitted to meet the specific conditions at each site. Greens were not watered daily. To the greatest extent possible, water was applied deeply and infrequently. During weeks 1-8, greens were subjected to only slight stress from localized dry spots on plots in the middle ranking of turf quality.
- *Weeks 9 through 12.* Plots were irrigated so that plots in the middle ranking of turf quality received moderate stress from localized dry spots. Plots were provided enough water to keep them alive. Some but not all plots should have shown visible, moderate stress from localized dry spots.
- *Weeks 13 through 16.* Plots were watered as described above for weeks 1-8.

Beyond the specific requirements for mowing height, mowing frequency, cultivation, topdressing and watering outlined above, the putting greens in the evaluation were maintained as high-quality putting turf using management practices appropriate for the local area. Turf plots were maintained to prevent substantial loss of turf in the control plots.

Interpretation of the results

The results from each evaluation site are summarized over the next 37 pages. A tremendous volume of data was collected at each site, and space limitations in *GCM* permit publication of only the key findings from each site and a limited amount of data to support those findings. The wetting agents are presented in the same order in each graph to help reduce confusion.

Readers are encouraged to find the evaluation site that is most similar to their golf course in terms of location, growing conditions and grass species and review the results from that site for help in making decisions regarding the performance of the wetting agents. We do not think it is appropriate to draw conclusions from a northern evaluation site for use on a golf course in the South and vice versa.

The complete set of summarized data for all sites and the entire scientific protocol used to conduct the evaluation are available at www.eifg.org.

Acknowledgments

I would like to acknowledge the nine cooperators who conducted the study and devoted many hours and untold energy to making it a success: John Cisar, Ph.D.; Barb Corvin, Ph.D.; Kevin Frank, Ph.D.; Keith Karnok, Ph.D.; Joe Krausz, Ph.D.; Bernd Leinauer, Ph.D.; Eric Miltner, Ph.D.; Sowmya Mitra, Ph.D.; and Frank Rossi, Ph.D. In addition, I would like to thank Jeff Nus, Ph.D., former director of research for GCSAA and current manager of Green Section research for USGA, who played a critical role in the development of the product evaluation concept that was implemented in the project.

Literature cited

1. Karnok, K.J., and K.A. Tucker. 2002. Water-repellent soils. Part I: Where are we now? *Golf Course Management* 70(6):59-62.
2. McCarty, L.B. 2001. Best golf course management practices. Prentice Hall, Upper Saddle River, N.J.

Clark Throssell, Ph.D. (cthrossell@gcsaa.org), is GCSAA's director of research.

WETTING AGENT STUDY

FLORIDA

Research cooperators: John L. Cisar, Ph.D. (jlc@cifl.edu), professor of environmental horticulture; D.M. Park, graduate student; and K.E. Williams, senior biologist, University of Florida Fort Lauderdale Research and Education Center

Research site: Otto Schmeisser Florida GCSA Research Green, University of Florida Fort Lauderdale Research and Education Center



Photo by K.E. Williams

Overview of the experimental area on March 19, 2004.



Construction method:

USGA recommendations

Soil texture: 97.0% sand, 1.9% silt, 1.0% clay

Root-zone organic matter: 3.04%

Thickness of thatch/mat: 0.625 inch (15.9 millimeters)

Yearly average hydrophobicity of control plots: 2003, 71 seconds; 2004, 104 seconds

Mowing height: 0.156 inch (4 millimeters)

Mowing frequency: 6 days/week

Cultivar: Tifdwarf bermudagrass

Study dates: April 22 – Aug. 12, 2003; Feb. 16 – June 7, 2004

AVERAGE HIGH TEMPERATURE

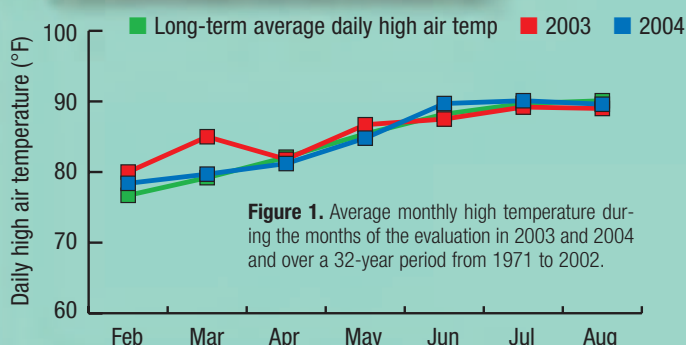


Figure 1. Average monthly high temperature during the months of the evaluation in 2003 and 2004 and over a 32-year period from 1971 to 2002.

MONTHLY PRECIPITATION

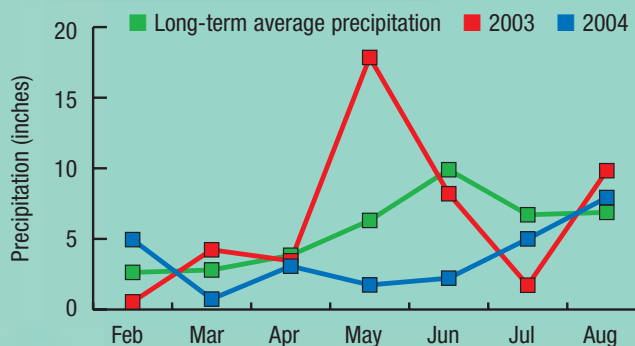


Figure 2. Total monthly precipitation during the months of the evaluation in 2003 and 2004 and the normal monthly precipitation total over a 32-year period from 1971 to 2002.

FLORIDA

Research cooperators: J.L. Cisar, Ph.D. (jlci@ufl.edu), professor of environmental horticulture; D.M. Park, graduate student; and K.E. Williams, senior biologist, University of Florida Fort Lauderdale Research and Education Center

Research site: Otto Schmeisser Florida GCSA Research Green, University of Florida Fort Lauderdale Research and Education Center

SUMMARY

South Florida has a subtropical climate, with a wet season from May through October followed by a dry season from November through April. Wet-season weather is characterized by high temperatures with intense rainfall occurring frequently in the afternoons. Dry-season weather is characterized by high evapotranspiration (ET) conditions (high temperatures and windy) with infrequent yet intense rainfall. The rapid wetting and drying cycles and high ET create an optimal environment for the development of soil water repellency. For both 2003 and 2004, significant differences were found among wetting agents and between wetting agents and the non-treated (control) turfgrass.

WDPT, 2003

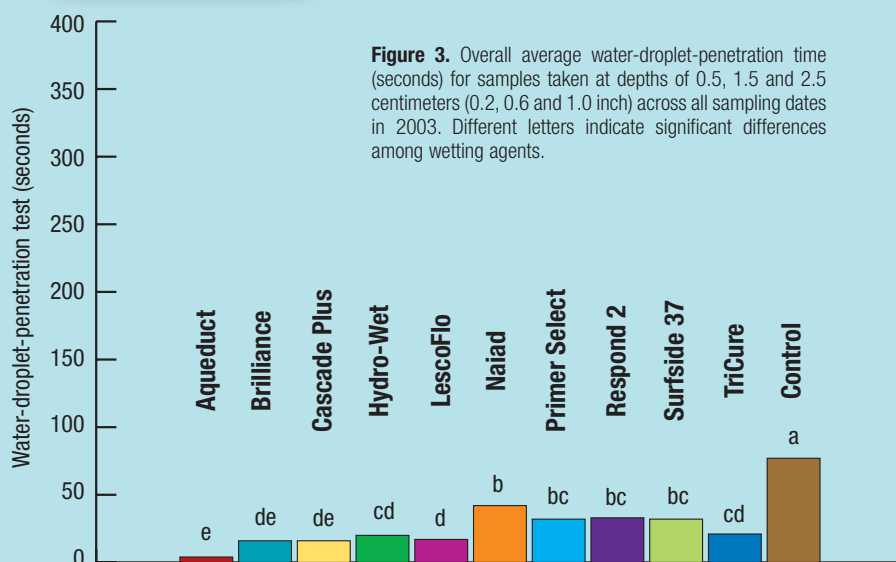


Figure 3. Overall average water-droplet-penetration time (seconds) for samples taken at depths of 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1.0 inch) across all sampling dates in 2003. Different letters indicate significant differences among wetting agents.

WDPT, 2004

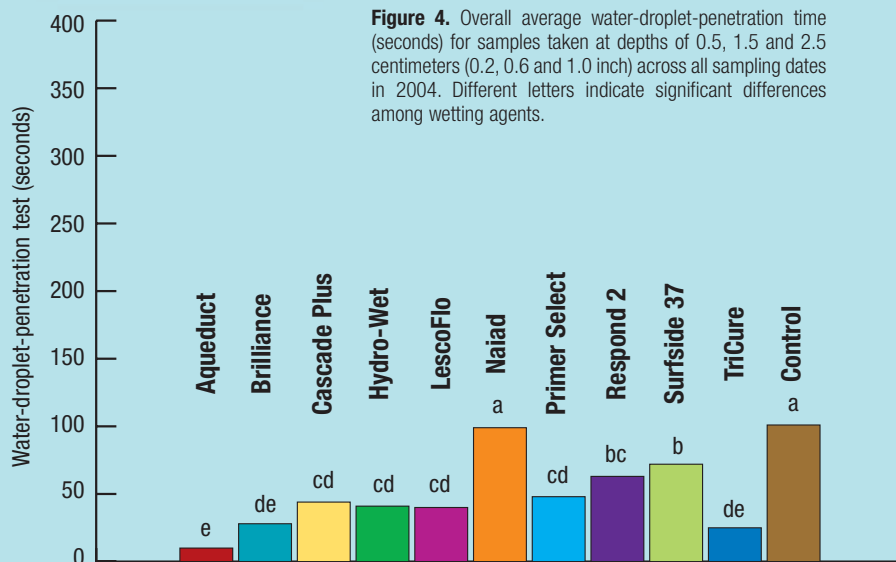


Figure 4. Overall average water-droplet-penetration time (seconds) for samples taken at depths of 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1.0 inch) across all sampling dates in 2004. Different letters indicate significant differences among wetting agents.

WETTING AGENT STUDY

TEXAS

Research cooperator: Joseph P. Krausz, Ph.D. (krausz@ag.tamu.edu), professor and Extension specialist, plant pathology and microbiology, Texas A&M University, College Station

Research site: Texas A&M University Turfgrass Field Laboratory, College Station



Photo courtesy of J.P. Krausz

The wetting agent evaluation site in Texas was at the Texas A&M University Turfgrass Field Laboratory in College Station.

PUTTING GREEN CHARACTERISTICS

Construction method: USGA recommendations

Soil texture: 97.8% sand, 1.0% silt, 0.6% clay

Root-zone organic matter: 1.35%

Depth of thatch/mat: 0.25 inch (6.4 millimeters)

Yearly average hydrophobicity of control plots: 2003, 58 seconds; 2004, 11 seconds

Mowing height: 0.156 inch (4 millimeters)

Mowing frequency: 6 days/week

Cultivar: FloraDwarf bermudagrass

Study dates: May 20 – Sept. 2, 2003; May 4 – Aug. 31, 2004

AVERAGE HIGH TEMPERATURE

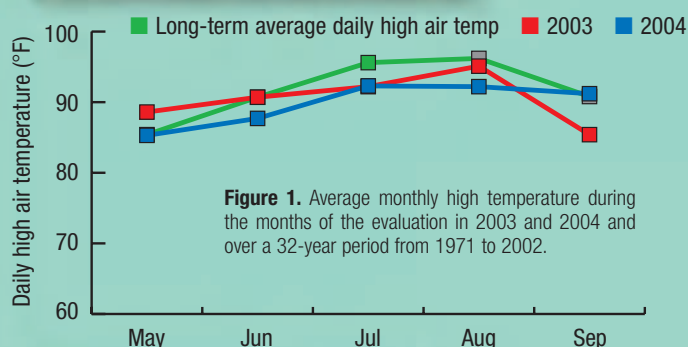


Figure 1. Average monthly high temperature during the months of the evaluation in 2003 and 2004 and over a 32-year period from 1971 to 2002.

MONTHLY PRECIPITATION

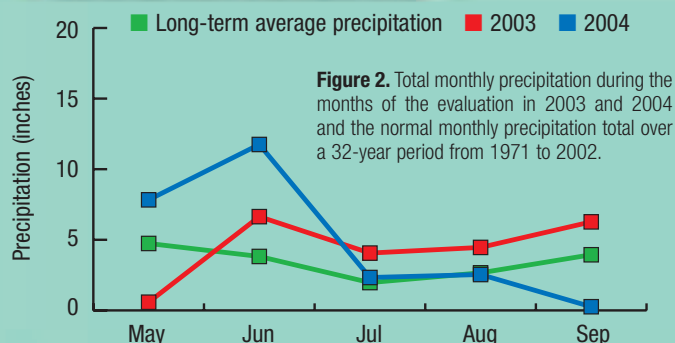


Figure 2. Total monthly precipitation during the months of the evaluation in 2003 and 2004 and the normal monthly precipitation total over a 32-year period from 1971 to 2002.

TURF COLOR, 2003



Figure 3. Mean ratings for turf color in 2003 (on a scale of 1-9, where 1 = brown and 9 = dark green). There were no significant differences among wetting agents.

TURF COLOR, 2004



Figure 4. Mean ratings for turf color in 2004 (on a scale of 1-9, where 1 = brown and 9 = dark green). There were no significant differences among wetting agents.

SUMMARY

- No significant differences in overall visual quality were observed among the treatments in either 2003 or 2004.
- Hydrophobicity was worse in the upper soil levels (depths of 0.5 and 1.5 centimeters) in 2003, but was much less of a problem in 2004, perhaps because of the abundant rainfall and relatively mild temperatures in 2004.
- In 2003, when hydrophobicity was a problem, none of the wetting agent treatments significantly reduced the hydrophobicity of the soil.
- In 2004, when hydrophobicity was much less of a problem compared to 2003, several wetting agent treatments — Aqueduct, Brilliance, Hydro-Wet, LescoFlo, Primer Select and TriCure — all significantly reduced hydrophobicity compared to the untreated check. However, the level of overall hydrophobicity was so low as to be insignificant, and it is doubtful that differences among treatments were agronomically significant.
- In summary, none of the wetting agent treatments significantly improved turfgrass color or quality in either 2003 or 2004.

WDPT, 2003

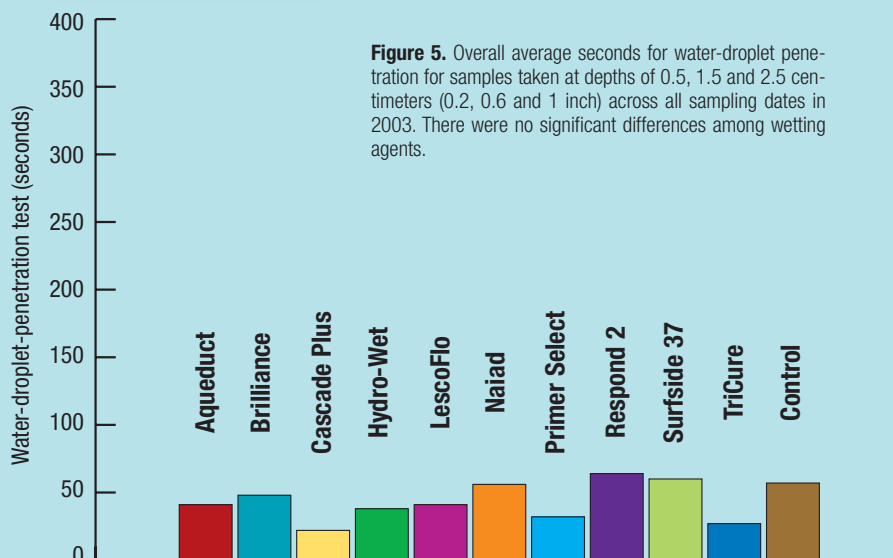


Figure 5. Overall average seconds for water-droplet penetration for samples taken at depths of 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1 inch) across all sampling dates in 2003. There were no significant differences among wetting agents.

WDPT, 2004

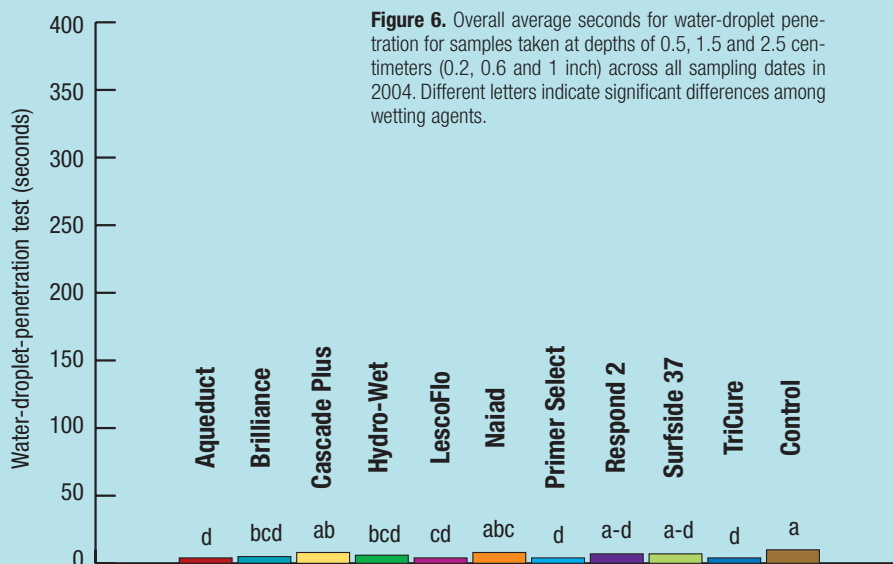


Figure 6. Overall average seconds for water-droplet penetration for samples taken at depths of 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1 inch) across all sampling dates in 2004. Different letters indicate significant differences among wetting agents.

WETTING AGENT STUDY

NEW MEXICO

Research cooperators:

Bernd Leinauer, Ph.D.
(leinauer@nmsu.edu), Extension specialist, Extension plant sciences, New Mexico State University, Las Cruces

Research site: New Mexico State University Golf Course, Las Cruces



Photo courtesy of B. Leinauer

The study site was a putting green at New Mexico State University's golf course in Las Cruces.

PUTTING GREEN CHARACTERISTICS

Construction method:

Modified California style

Soil texture: 97% sand, 2% silt, 1% clay

Root-zone organic matter: <1%

Thickness of thatch/mat: 0.125 inch (3.2 millimeters)

Yearly average hydrophobicity of control plots:

2003, 96 seconds; 2004, 56 seconds

Mowing height: 0.110 inch (2.8 millimeters)

Mowing frequency: daily

Cultivar: Pennncross creeping bentgrass

Study dates: June 1 – Oct. 8, 2003; May 17 – Sept. 13, 2004

AVERAGE HIGH TEMPERATURE

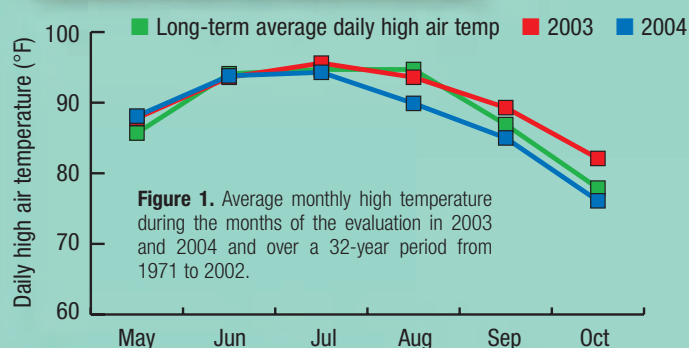


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MONTHLY PRECIPITATION

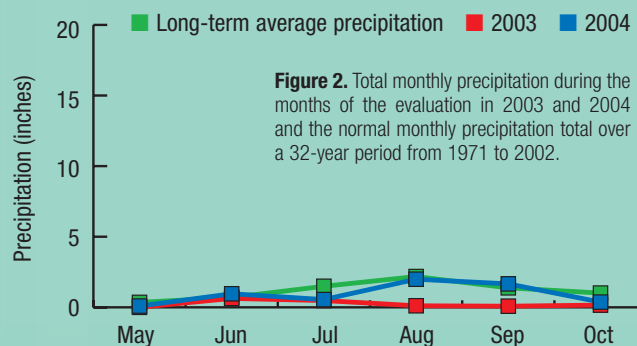


Figure 2. Total monthly precipitation during the months of the evaluation in 2003 and 2004 and the normal monthly precipitation total over a 32-year period from 1971 to 2002.

TURF COLOR, 2003



Figure 3. Mean ratings for turf color in 2003 (on a scale of 1-9, where 1 = brown and 9 = dark green). Data are averaged over all sampling dates for each year. There were no significant differences among wetting agents.

TURF COLOR, 2004



Figure 4. Mean ratings for turf color in 2004 (on a scale of 1-9, where 1 = brown and 9 = dark green). Data are averaged over all sampling dates for each year. There were no significant differences among wetting agents.

NEW MEXICO

Research cooperator: Bernd Leinauer, Ph.D., New Mexico State University, Las Cruces

Research site: New Mexico State University Golf Course, Las Cruces

WDPT, 2003-2004

Product	0.5 cm*		1.5 cm*		2.5 cm	
	2003	2004	2003	2004	2003	2004
Aqueduct	75 abcd	5 c	75 abc	20 e	61	50
Brilliance	32 e	7 c	60 bc	21 de	55	51
Cascade Plus	45 de	6 c	83 abc	27 de	75	55
Hydro-Wet	57 cde	7 c	84 abc	33 de	47	54
LescoFlo	35 e	6 c	55 c	27 de	59	58
Naiad	99 ab	51 ab	103 ab	67 a	92	79
Primer Select	68 bcde	5 c	69 bc	22 de	47	63
Respond 2	109 a	34 b	87 abc	51 bc	62	64
Surfside 37	92 abc	12 c	91 abc	37 cd	74	59
TriCure	85 abc	3 c	64 bc	25 de	59	59
Control	103 ab	52 a	118 a	59 ab	77	65

Note. Numbers in a column followed by the same letter are not significantly different from one another.

Table 1. Water-droplet-penetration time at depths of 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1 inch) for 2003 and 2004. Data are averaged over all sampling dates for each year.

SUMMARY

- There were no statistical differences among treatments for mean color ratings for 2003 and 2004.
- In both years, the control treatment and plots treated with Naiad and Respond 2 wetting agents showed highest water-droplet-penetration time (WDPT) at all depths. In 2003, the products Brilliance, Cascade Plus, Hydro-Wet and LescoFlo, differed significantly from the control treatment at the 0.5-centimeter (0.2-inch) depth. At the 1.5-centimeter depth, Brilliance, LescoFlo, Primer Select and TriCure showed a significant difference from the control treatment for WDPT. In 2004, Naiad did not differ significantly from the control treatment in WDPT at depths of 0.5 centimeter and 1.5 centimeters (0.2 and 0.6 inch) and had the highest reported WDPT for all treatments. Respond 2 also had no significant effect on WDPT compared to the control at the 1.5-centimeter depth. In 2003 and 2004, none of the applied surfactants differed significantly from the control treatment at the 2.5-centimeter (1-inch) depth.
- Most other products in the study appeared to alleviate water repellency to various degrees at depths of 0.5 centimeter and 1.5 centimeters (0.2 and 0.6 inch) as indicated by WDPTs lower than that of the control treatment.

ACKNOWLEDGMENTS

The support of Bruce Erhard, a 22-year GCSAA member and superintendent at New Mexico State University's golf course; the Rio Grande GCSA; and the Southwest Turfgrass Association is greatly appreciated. Without their generous help, this study would not have been possible.

WETTING AGENT STUDY

CALIFORNIA

Research cooperators:

Sowmya (Shoumo) Mitra, Ph.D.
(smitra@csupomona.edu), associate professor, department of plant science, graduate program coordinator, California State Polytechnic University, Pomona

Research site: Montebello (Calif.) Golf Course



Photo courtesy of Sowmya Mitra

Russell Plumb (left), a graduate student at Cal Poly – Pomona, collects soil cores with Juan Perez, assistant superintendent at Montebello GC, who conducted the 2003 wetting agent test for his senior project at the university. Perez, a four-year GCSAA member, is currently assistant superintendent at Vellano CC, Chino Hills, Calif.

PUTTING GREEN CHARACTERISTICS

Construction method:

USGA recommendations

Soil texture: 92% sand, 4.8% silt, 2.2% clay

Root-zone organic matter: 1.62%

Thickness of thatch/mat: 0.75 inch (19.1 millimeters)

Yearly average hydrophobicity of control plots:

2003, 234 seconds; 2004, 399 seconds

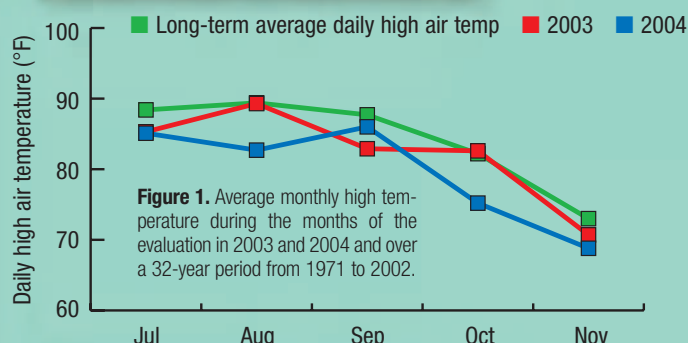
Mowing height: 0.140 inch (3.6 millimeters)

Mowing frequency: 6 days/week

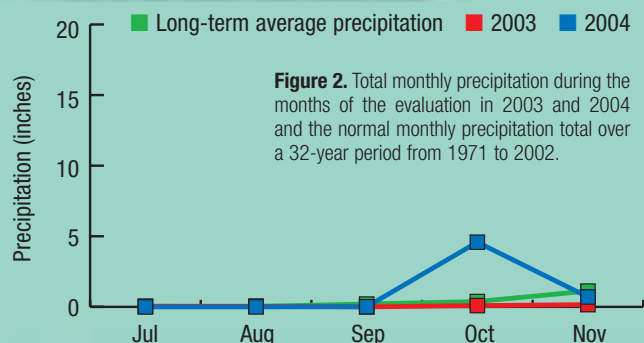
Cultivar: 80% Dominant creeping bentgrass blend and 20% annual bluegrass

Study dates: July 29 – Nov. 18, 2003; July 22 – Nov. 10, 2004

AVERAGE HIGH TEMPERATURE



MONTHLY PRECIPITATION



PHYTOTOXICITY, 2004



Figure 3. Phytotoxicity observed in 2004 on the third day after the first application for all wetting agents (on a scale of 1-9, where 1 = brown or discolored turf and 9 = no damage). Different letters indicate significant differences among wetting agents.

TURF COLOR, 2003



Figure 4. Mean ratings for turf color in 2003 (on a scale of 1-9, where 1 = brown and 9 = dark green). Different letters indicate significant differences among wetting agents.

Research site: Montebello (Calif.) Golf Course

SUMMARY

- No phytotoxicity was observed in 2003, but significant injury was observed in 2004. The difference in response could be due to the change in weather conditions between the two years.
- In 2004, Cascade Plus caused the greatest phytotoxicity at one and three days after treatment.
- The most hydrophobic regions were at depths of 1.5 and 2.5 centimeters (0.6 and 1.0 inch) for both years.
- All the wetting agent treatments reduced dew formation on the turf compared to the control.
- In both years, Aqueduct, Hydro-Wet, LescoFlo, Primer Select, Surfside 37 and TriCure significantly reduced dew formation seven days after application compared to the other products in the study.
- Overall, based on the average water-droplet-penetration test in 2003, Aqueduct, Brilliance, Cascade Plus, LescoFlo, Primer Select and TriCure significantly reduced hydrophobicity compared to the control and Respond 2. There was no difference among the Respond 2, Naiad, Hydro-Wet and Surfside 37 treatments.
- In 2004, according to the overall average water-droplet-penetration test, Aqueduct reduced hydrophobicity significantly compared to the control, Brilliance, Hydro-Wet, LescoFlo, Naiad, Primer Select, Respond 2, Surfside 37 and TriCure. The Aqueduct and Cascade Plus treatments were not significantly different. There were no significant differences among the Brilliance, Cascade Plus, Hydro-Wet, LescoFlo, Primer Select and TriCure treatments.

ACKNOWLEDGMENTS

I greatly appreciate the help and support I received from Fernando Garcia, six-year GCSAA member and superintendent at Montebello Golf Course; Juan Perez (Senior Project 2003); Kevin White (Senior Project 2004); Kent Kurtz, Ph.D.; Russell Plumb; Bianca Good; Himani Swami; Paitawee Suphandrita; and Magdy Fam.

WDPT, 2003

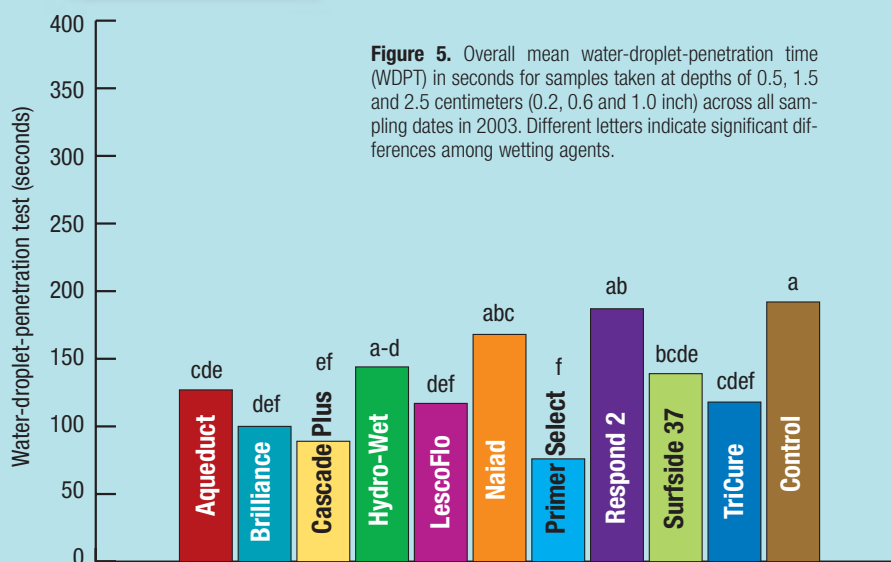


Figure 5. Overall mean water-droplet-penetration time (WDPT) in seconds for samples taken at depths of 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1.0 inch) across all sampling dates in 2003. Different letters indicate significant differences among wetting agents.

WDPT, 2004

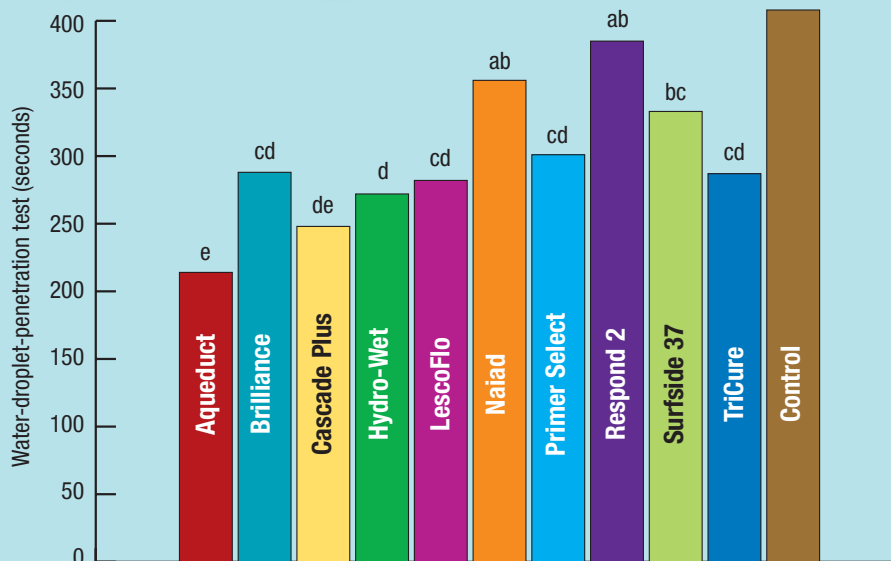


Figure 6. Overall mean WDPT for samples taken at depths of 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1.0 inch) across all sampling dates in 2004. Different letters indicate significant differences among wetting agents.

WETTING AGENT STUDY

GEORGIA

Research cooperators: Keith J. Karnok, Ph.D. (kkarnok@uga.edu), professor in the department of crop and soil sciences, and Kevin Tucker, research assistant, University of Georgia, Athens

Research site: University of Georgia Rhizotron and Turfgrass Facility, Athens



Photo courtesy of K.J. Karnok

The study site was located at the University of Georgia's turfgrass facility in Athens.

PUTTING GREEN CHARACTERISTICS

Construction method:

USGA recommendations

Soil texture: 96.1% sand, 2.3% silt, 1.4% clay

Root-zone organic matter: 1.9%

Thickness of thatch/mat:

0.1875 inches (4.8 millimeters)

Yearly average hydrophobicity of control plots:

2003, 180 seconds; 2004, 194 seconds

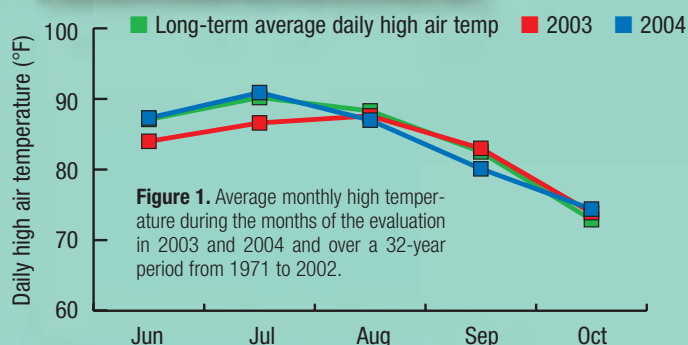
Mowing height: 0.140 inch (3.6 millimeters)

Mowing frequency: 6 days/week

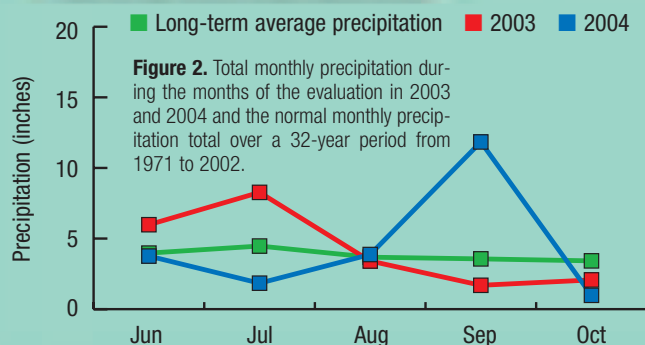
Cultivar: Penncross creeping bentgrass

Study dates: June 4 – Oct. 1, 2003; June 7 – Oct. 4, 2004

AVERAGE HIGH TEMPERATURE



MONTHLY PRECIPITATION



PHYTOTOXICITY, 2003

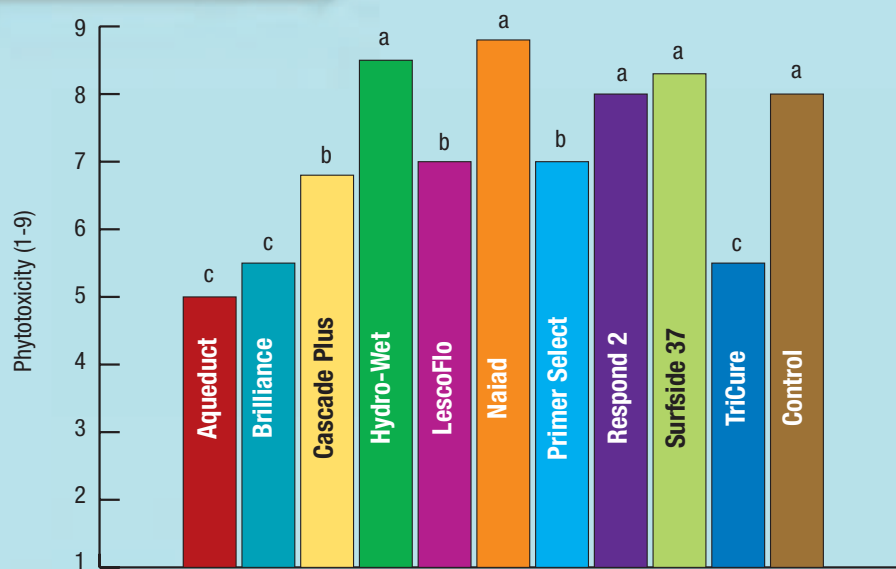


Figure 3. Phytotoxicity seven days after treatment in 2003 (on a scale of 1-9, where 1 = brown or discolored turf and 9 = no damage). Only the first phytotoxicity rating date is shown for 2003. Different letters indicate significant differences among wetting agents.

PHYTOTOXICITY, 2004

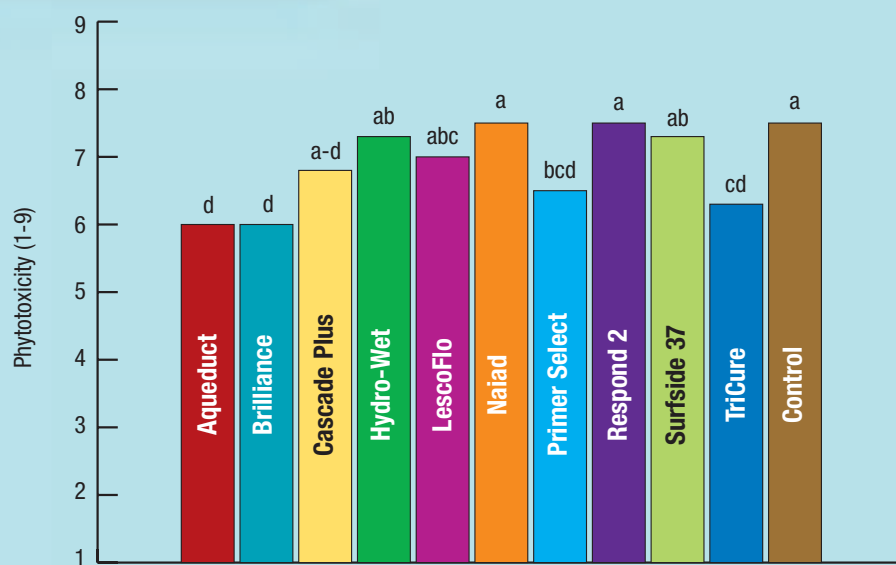


Figure 4. Phytotoxicity seven days after treatment in 2004 (on a scale of 1-9, where 1 = brown or discolored turf and 9 = no damage). Only the first phytotoxicity rating date is shown for 2004. Different letters indicate significant differences among wetting agents.

WETTING AGENT STUDY

GEORGIA

TURF QUALITY, 2003

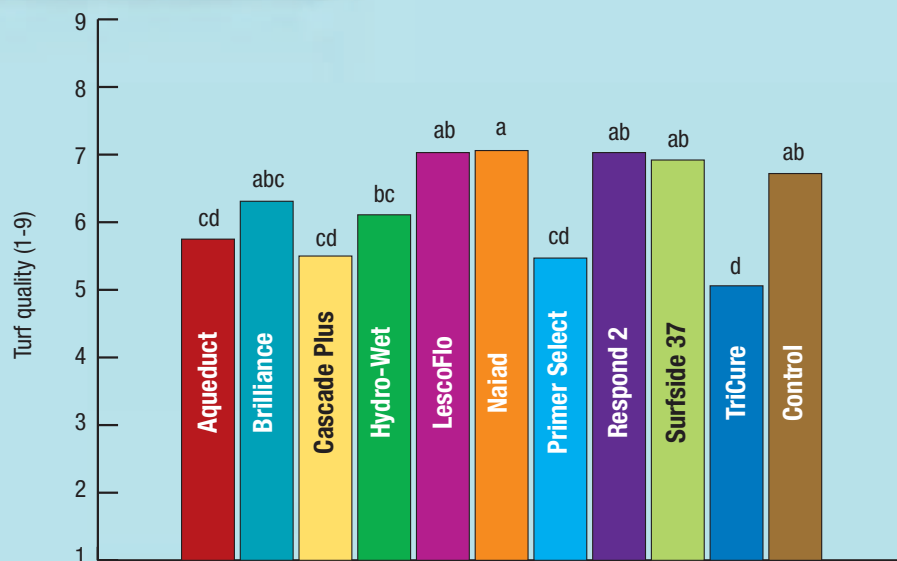


Figure 5. Mean turf quality ratings in 2003 (on a scale of 1-9, where 1 = poor and 9 = excellent). Different letters indicate significant differences among wetting agents.

TURF QUALITY, 2004

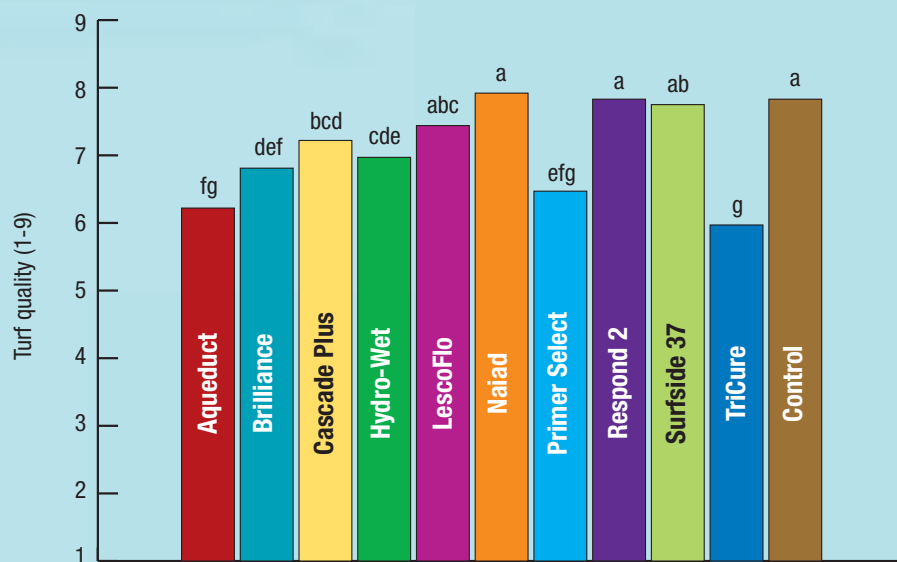


Figure 6. Mean ratings for turf quality in 2004 (on a scale of 1-9, where 1 = poor and 9 = excellent). Different letters indicate significant differences among wetting agents.

GEORGIA

Research cooperators: Keith J. Karnok, Ph.D., and Kevin Tucker, University of Georgia, Athens

Research site: University of Georgia Rhizotron and Turfgrass Facility, Athens

WDPT, 2003

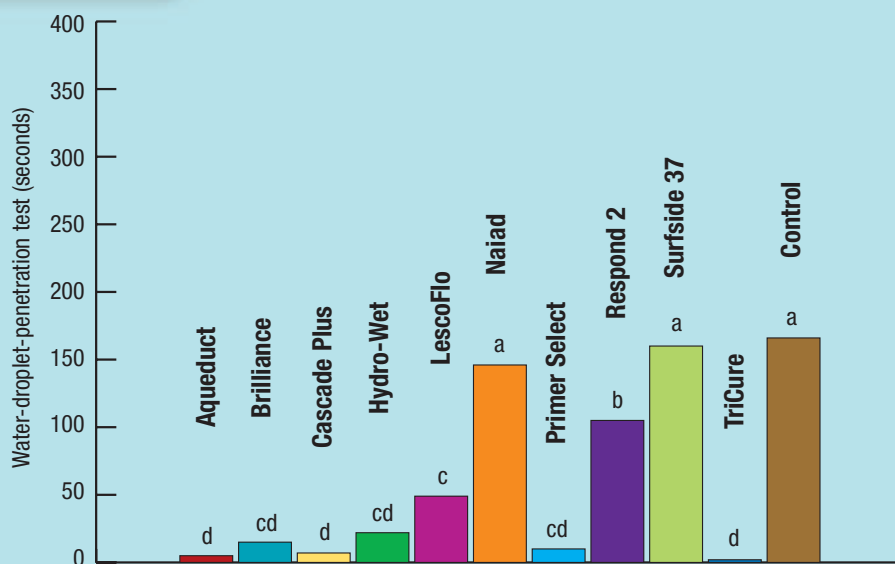


Figure 7. Water-droplet-penetration time (WDPT) in seconds averaged over depths of 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1 inch) and over all sampling dates for 2003. Different letters indicate significant differences among wetting agents.

WDPT, 2004

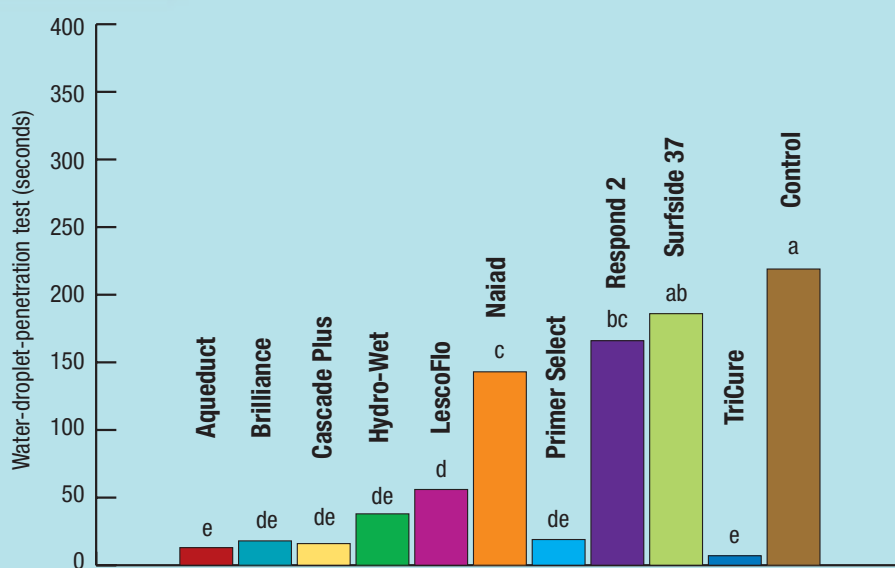


Figure 8. WDPT in seconds averaged over depths of 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1 inch) and over all sampling dates for 2004. Different letters indicate significant differences among wetting agents.

DISCUSSION AND RESULTS

The control showed the best turfgrass quality throughout the study. Water-repellent soils have a critical moisture point. Above this point, the soil will not show signs of water repellency. Below this point, the soil will begin to repel water, and localized dry spots will become apparent. This critical moisture point varies among soils. In our case, with the irrigation regime used and greater-than-normal rainfall at times, the soil moisture content was often above the critical point, and the control showed few signs of localized dry spots.

This fact does not influence the WDPT data because the soil samples were dried below the critical moisture point before testing. To us, this is the true indicator of how well a wetting agent relieves soil water repellency. The quality data shown here most likely represent the stress the wetting agent put on the turfgrass rather than the effects of water-repellent soil. Certainly, different environments, cultural practices, soil types, and species and cultivar of turfgrass could result in different findings.

SUMMARY

- Hydro-Wet, Naiad, Respond 2 and Surfside 37 were the only wetting agents that showed no significant phytotoxicity for both 2003 and 2004.
- Aqueduct, Brilliance, Primer Select and TriCure showed significant phytotoxicity compared to the control in both years. In most cases, the wetting agents with the greatest potential for causing phytotoxicity did so during the periods of greatest turfgrass summer stress.
- LescoFlo, Naiad, Respond 2 and Surfside 37 did not reduce turfgrass quality compared to the control for 2003 and 2004.
- Phytotoxicity was most severe during the peak summer stress months.
- Aqueduct, Cascade Plus, Hydro-Wet, Primer Select and TriCure all reduced turf quality compared to the control in both years.
- The greatest soil water repellency occurred in the top 2.5 centimeters (1 inch) of the soil profile.
- Soil water repellency was most severe toward the end of summer in both years.
- Surfside 37, Naiad and Respond 2 were the least effective in reducing soil water repellency.
- Aqueduct, Brilliance, Cascade Plus, Hydro-Wet, LescoFlo, Primer Select and TriCure significantly reduced soil water repellency in both years.
- In terms of reducing soil water repellency, the relative ranking of wetting agents remained essentially the same regardless of soil depth or degree of water repellency.

WETTING AGENT STUDY

MISSOURI

Research cooperators:

Barbara S. Corwin, Ph.D.
(CorwinB@missouri.edu), Extension
assistant professor, Ag Extension-
plant sciences, University of
Missouri, Columbia

Research site: The Club at Porto
Cima, Lake Ozark, Mo.



Photo courtesy of B. Corwin

The study site was located on a practice putting green at the Club at Porto Cima, Lake Ozark, Mo.

PUTTING GREEN CHARACTERISTICS

Construction method:

USGA recommendations

Soil texture: 97.9 % sand, 0.8% silt,
1.0% clay

Root-zone organic matter: 0.84%

Thickness of thatch/mat: 0.75 inch
(19.05 millimeters)

**Yearly average hydrophobicity of
control plots:** 2003, 18 seconds;
2004, 18 seconds

Mowing height: 0.110 – 0.125 inch
(2.8-3.2 millimeters)

Mowing frequency: daily

Cultivar: G-2 creeping bentgrass

Study dates: May 12 – Sept. 9, 2003;
May 17, 2004 – Sept. 21, 2004

AVERAGE HIGH TEMPERATURE

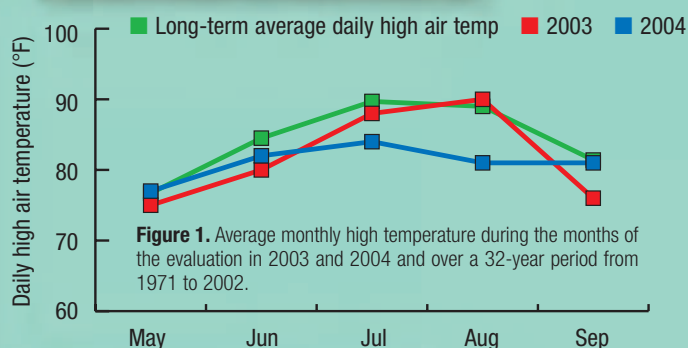


Figure 1. Average monthly high temperature during the months of the evaluation in 2003 and 2004 and over a 32-year period from 1971 to 2002.

MONTHLY PRECIPITATION

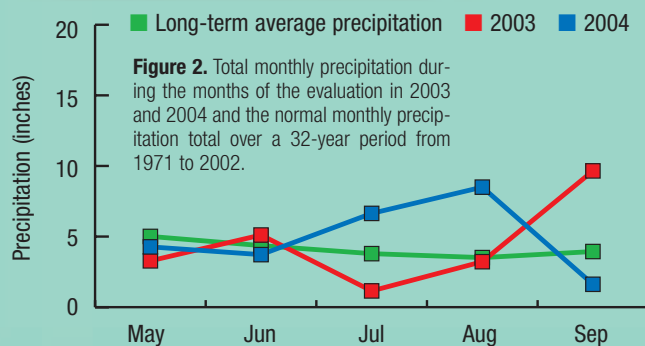


Figure 2. Total monthly precipitation during the months of the evaluation in 2003 and 2004 and the normal monthly precipitation total over a 32-year period from 1971 to 2002.

TURF COLOR, 2003



Figure 3. Mean turf color ratings for 2003 (on a scale of 1-9, where 1 = brown and 9 = dark green). Data are averaged over all sampling dates for one year. Different letters indicate significant differences among wetting agents.

TURF COLOR, 2004



Figure 4. Mean turf color ratings for 2004 (on a scale of 1-9, where 1 = brown and 9 = dark green). Data are averaged over all sampling dates for one year. There were no significant differences among wetting agents.

MISSOURI

Research cooperator: Barbara S. Corwin, Ph.D., University of Missouri, Columbia

Research site: The Club at Porto Cima, Lake Ozark, Mo.

SUMMARY

- In 2003, the average color rating for plots treated with Cascade Plus was significantly lower than the average color rating for the control as well as all other wetting agent treatments. The average color rating for plots treated with LescoFlo was significantly better than the average color rating for plots treated with Brilliance, Cascade Plus and HydroWet, but did not differ significantly from the control.
- There were no significant differences in color rating among treatments in 2004.
- The root zone of the putting green at this study site had a slight degree of water repellency during the course of this study.
- Although statistically significant differences were observed among treatments in both 2003 and 2004, there was only an 11-second difference in water droplet penetration between the longest mean time and the shortest mean time in both years. It is doubtful the differences in mean water-droplet-penetration times were agronomically meaningful.
- The products that were most effective in reducing soil hydrophobicity also reduced turfgrass color.

ACKNOWLEDGMENTS

I would like to thank Paul Naudet, superintendent, and Mike Renfro, turf equipment technician, at The Club at Porto Cima; 2003 summer interns Shea Nelson and Ben Stover from Iowa State University; and 2004 summer intern Kyle Briscoe from the University of Missouri.

WDPT, 2003

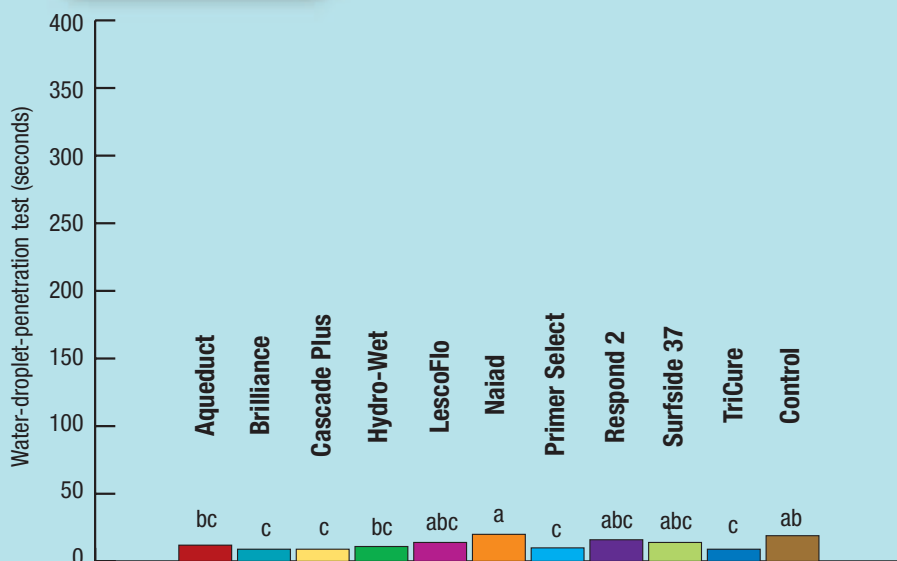


Figure 5. WDPT (seconds) averaged over 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1 inch) and over all sampling dates for 2003. Different letters indicate significant differences among wetting agents.

WDPT, 2004

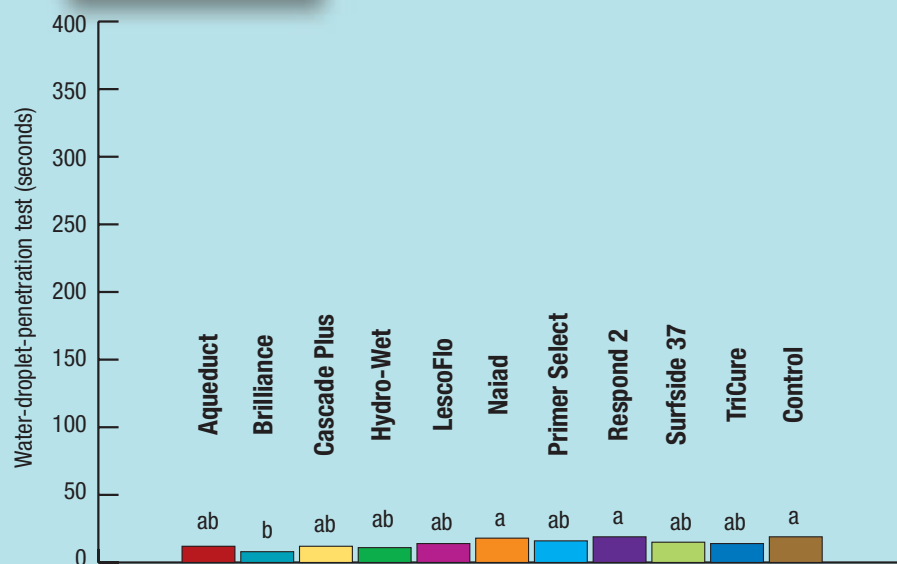


Figure 6. WDPT (seconds) averaged over 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1 inch) and over all sampling dates for 2004. Different letters indicate significant differences among wetting agents.

WETTING AGENT STUDY

NEW YORK

Research cooperators:

Frank S. Rossi, Ph.D.
(fsr3@cornell.edu),
associate professor, department of
horticulture, Cornell University,
Ithaca, N.Y.

Research site: Cornell Turfgrass
and Landscape Research Laboratory,
Ithaca, N.Y.



Photo courtesy of Frank S. Rossi

The study site was at the Cornell Turfgrass and Landscape Research and Education Center, Ithaca, N.Y.

PUTTING GREEN CHARACTERISTICS

Construction method:

100%-sand California profile

Soil texture:

98% sand, 2% silt and clay

Root-zone organic matter: 0.9%

Thickness of thatch/mat: 0.25 inch
(6.4 millimeters)

Yearly average hydrophobicity of

control plots: 2003, 12 seconds;
2004, 20 seconds

Mowing height: 0.100 inch
(2.5 millimeters)

Mowing frequency: 7 days/week

Cultivar: 80% SR 1119 creeping bent-
grass and 20% annual bluegrass

Study dates: June 1 – Nov. 1, 2003;
June 5 – Nov. 8, 2004

AVERAGE HIGH TEMPERATURE

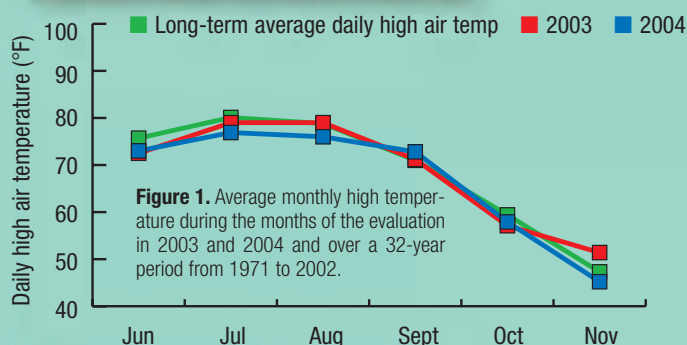


Figure 1. Average monthly high temperature during the months of the evaluation in 2003 and 2004 and over a 32-year period from 1971 to 2002.

MONTHLY PRECIPITATION

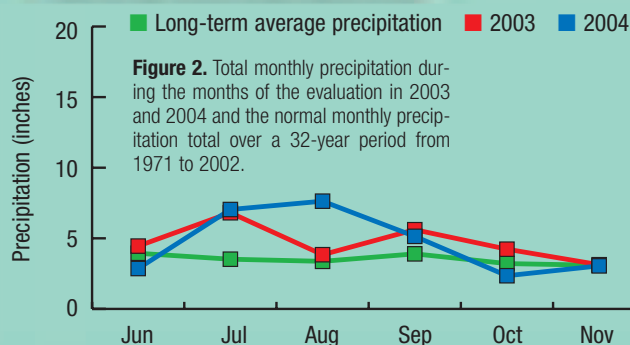


Figure 2. Total monthly precipitation during the months of the evaluation in 2003 and 2004 and the normal monthly precipitation total over a 32-year period from 1971 to 2002.

TURF QUALITY, 2003 and 2004



Figure 3. Average 2003-2004 turf quality ratings in response to wetting agent applications (on a scale of 1-9, where 1 = poor and 9 = excellent). There were no significant differences among wetting agents.

NEW YORK

Research cooperator: Frank S. Rossi, Ph.D., Cornell University, Ithaca, N.Y.

Research site: Cornell Turfgrass and Landscape Research Laboratory, Ithaca, N.Y.

SUMMARY

- In general, the 2003 and 2004 growing seasons were among the wettest in the last 100 years in central New York state. Both years experienced above-average rainfall; rainfall in 2004 was 12 inches (30.5 centimeters) above normal for the months of the study.
- There were no significant differences in mean turf-quality ratings averaged over the two years among the treatments (Figure 3). Phytotoxicity data (not shown) do not reveal any obvious injury associated with the treatments.
- There were significant statistical differences among the wetting agents in both years of the study (Figures 4, 5). However, as the data indicate, this site did not exhibit the severe water repellency we have observed in years of normal rainfall. Therefore, we do not believe there were biologically meaningful differences among the treatments.
- The conclusion from the two-year study at our location suggests that a sand green historically prone to localized dry spot may benefit from wetting agent use, and some wetting agents do appear to be better than others. However, when rainfall is above average, greens do not require supplemental wetting agent treatments for water repellency.

WDPT, 2003

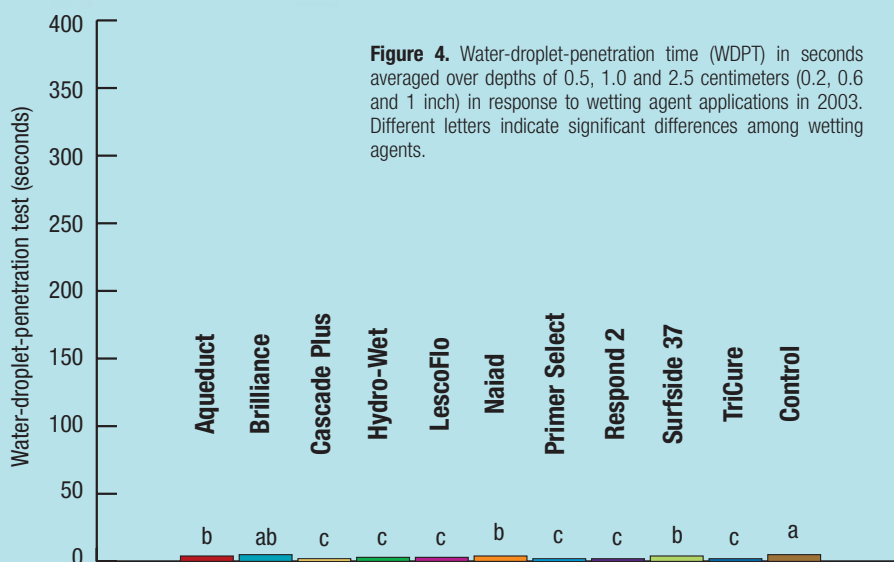


Figure 4. Water-droplet-penetration time (WDPT) in seconds averaged over depths of 0.5, 1.0 and 2.5 centimeters (0.2, 0.6 and 1 inch) in response to wetting agent applications in 2003. Different letters indicate significant differences among wetting agents.

WDPT, 2004

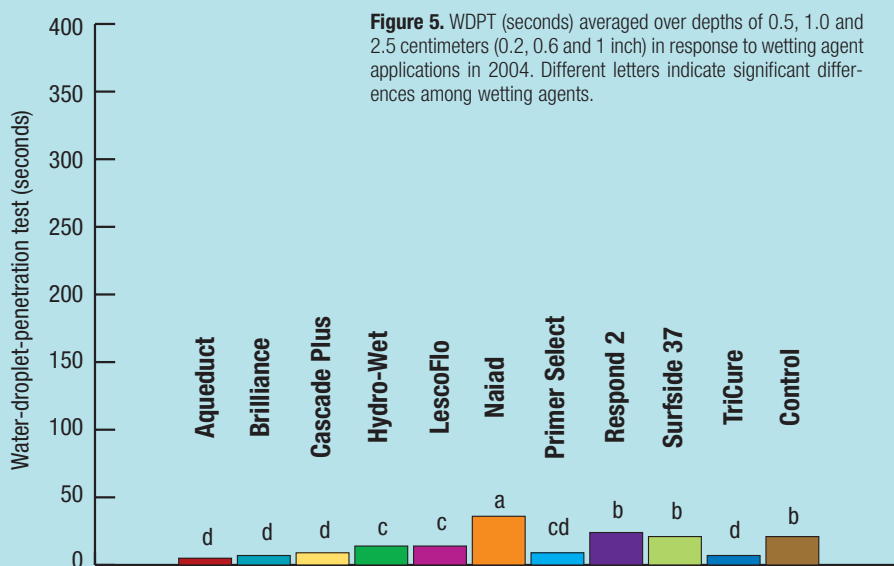


Figure 5. WDPT (seconds) averaged over depths of 0.5, 1.0 and 2.5 centimeters (0.2, 0.6 and 1 inch) in response to wetting agent applications in 2004. Different letters indicate significant differences among wetting agents.

WETTING AGENT STUDY

MICHIGAN

Research cooperators:

Kevin W. Frank, Ph.D.
(frankk@msu.edu), assistant professor, and Jeff Bryan, research technician, department of crop and soil sciences, Michigan State University, East Lansing

Research site: Hancock Turfgrass Research Center, Michigan State University, East Lansing



Photo courtesy of Kevin Frank

The wetting agent evaluation was conducted at the Hancock Turfgrass Research Center on the campus of Michigan State University.

PUTTING GREEN CHARACTERISTICS

Construction method:

USGA recommendations

Soil texture: 87.7% sand, 9.9% gravel, 1.2% silt, 1.2% clay

Root-zone organic matter: 0.29%

Thickness of thatch/mat depth:

0.4-inch (10.2 millimeters)

Yearly average hydrophobicity of control plots:

2003, 340 seconds;
2004, 322 seconds

Mowing height:

0.156 inch
(4 millimeters)

Mowing frequency:

6 days/week

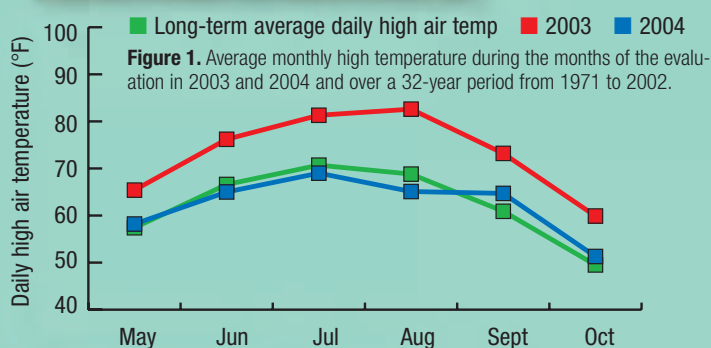
Cultivar:

L-93 creeping bentgrass

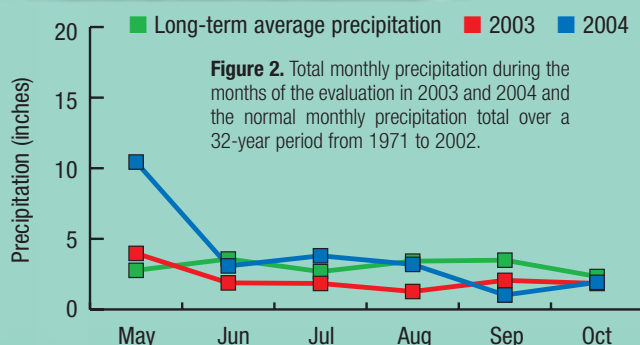
Study dates:

June 16 – Oct. 7, 2003;
May 27 – Oct. 7, 2004

AVERAGE HIGH TEMPERATURE



MONTHLY PRECIPITATION



TURF QUALITY, 2003

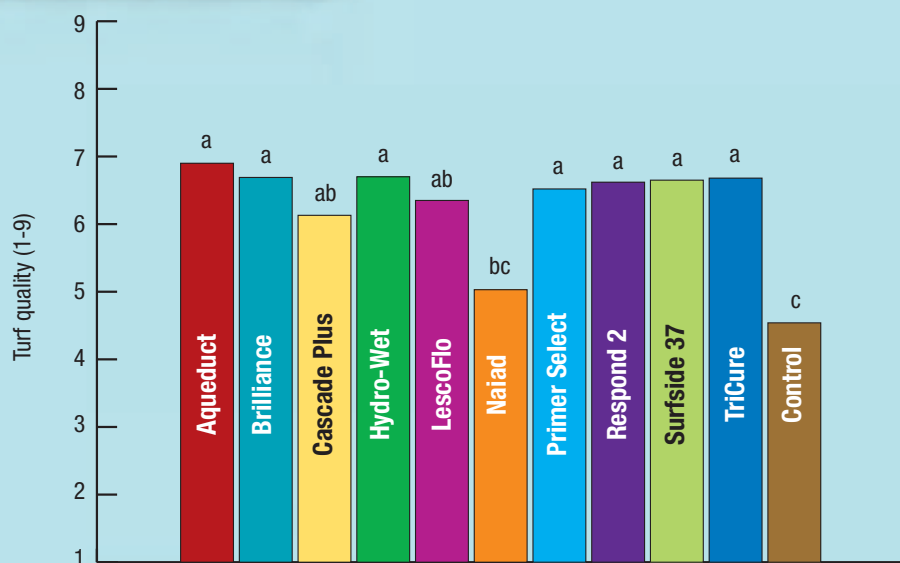


Figure 3. Overall mean turf quality ratings for 2003 (on a scale of 1-9, where 1 = poor and 9 = excellent). Different letters indicate significant differences among wetting agents.

TURF QUALITY, 2004

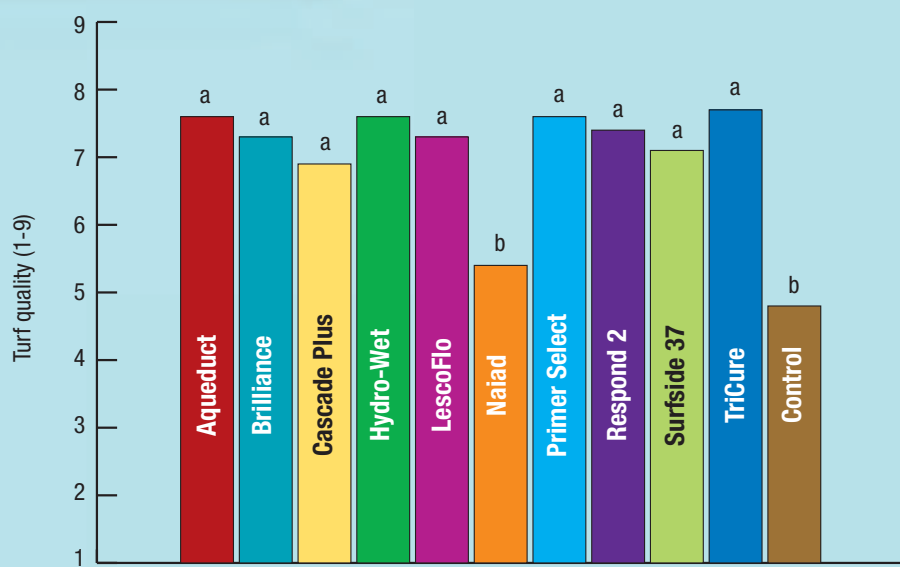


Figure 4. Overall mean turfgrass quality ratings for 2004 (on a scale of 1-9, where 1 = poor and 9 = excellent). Different letters indicate significant differences among wetting agents.

MICHIGAN

Research cooperators: Kevin W. Frank, Ph.D., and Jeff Bryan, Michigan State University, East Lansing

Research site: Hancock Turfgrass Research Center, Michigan State University, East Lansing

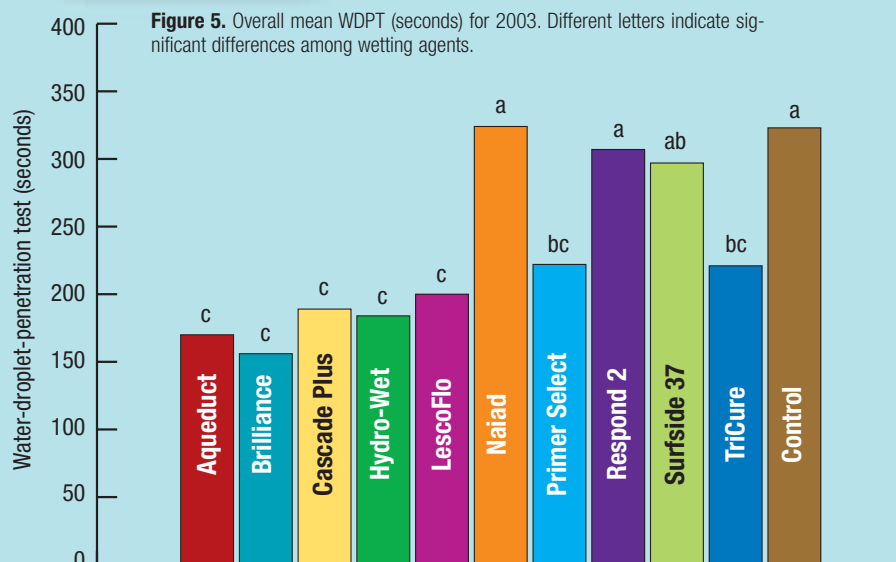
SUMMARY

Mean turfgrass quality ratings from 2003 and 2004 were similar. Naiad and the untreated control were the only treatments that were significantly different in both years; they also had the lowest quality ratings.

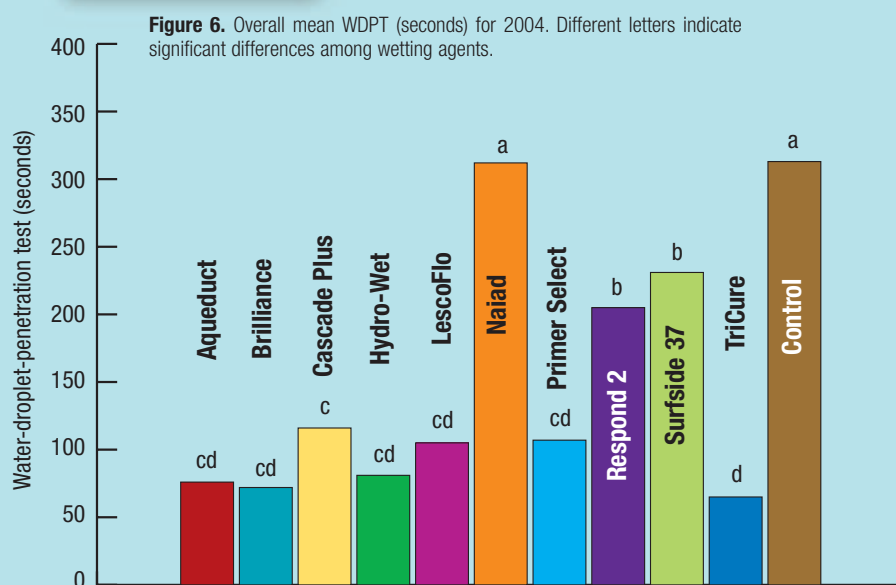
Mean water-droplet-penetration-test results were averaged over depths of 0.5, 1.5 and 2.5 centimeters (0.2, 0.6 and 1 inch).

- **2003.** Plots treated with Naiad, Surfside 37, Respond 2 and the untreated control had the longest water-droplet-penetration times. Plots treated with Aqueduct, Brilliance, Cascade Plus, Hydro-Wet, LescoFlo, Primer Select and TriCure had the shortest times for water penetration and were statistically similar.
- **2004.** Plots treated with Naiad and the untreated control had the longest times for water penetration. Plots treated with Aqueduct, Brilliance, Hydro-Wet, LescoFlo, Primer Select and TriCure had the shortest times for water penetration and were statistically similar.

WDPT, 2003



WDPT, 2004



WETTING AGENT STUDY

WASHINGTON

Research cooperators:

Eric Miltner, Ph.D.
(miltner@wsu.edu), assistant
turfgrass research agronomist,
Washington State University, Puyallup

Research site: Washington State
University Puyallup Research and
Extension Center, Farm 5, Puyallup



Photo by Eric Miltner

The evaluation site was at the Washington State University Puyallup Research and Extension Center. The photo was taken in May 2004.

PUTTING GREEN CHARACTERISTICS

Construction method: Sand root zone,
with sand meeting USGA recommendations

Soil texture: 94.5% sand, 1.8% silt,
1.7% clay

Root-zone organic matter: 0.8%

Thickness of thatch/mat: 0.375 inch
(9.5 millimeters)

**Yearly average hydrophobicity of
control plots:** 2003, 218 seconds;
2004, 188 seconds

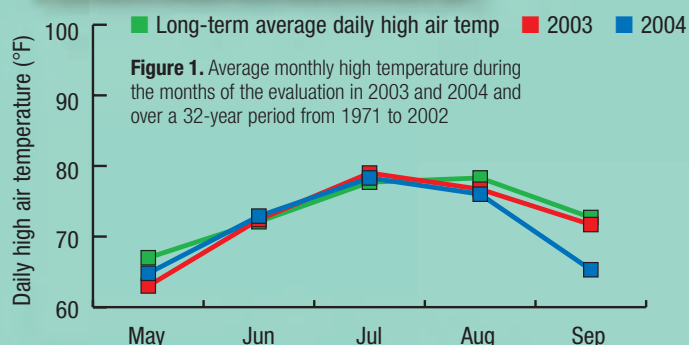
Mowing height: 0.135 inch
(3.4 millimeters)

Mowing frequency: 5-6 days/week

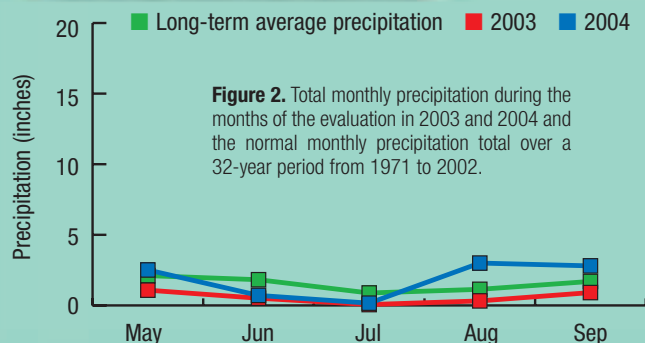
Cultivar: Century creeping bentgrass

Study dates: May 27 – Sept 17, 2003;
May 18 – Sept. 1, 2004

AVERAGE HIGH TEMPERATURE



MONTHLY PRECIPITATION



TURF QUALITY, 2003



Figure 3. Mean ratings for turf quality in 2003 (on a scale of 1-9, where 1 = poor and 9 = excellent). There were no significant differences among wetting agents.

TURF QUALITY, 2004



Figure 4. Mean ratings for turf quality in 2004 (on a scale of 1-9, where 1 = poor and 9 = excellent). There were no significant differences among wetting agents.

WASHINGTON

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Research site: Washington State University Puyallup Research and Extension Center, Farm 5, Puyallup

WDPT, 2003

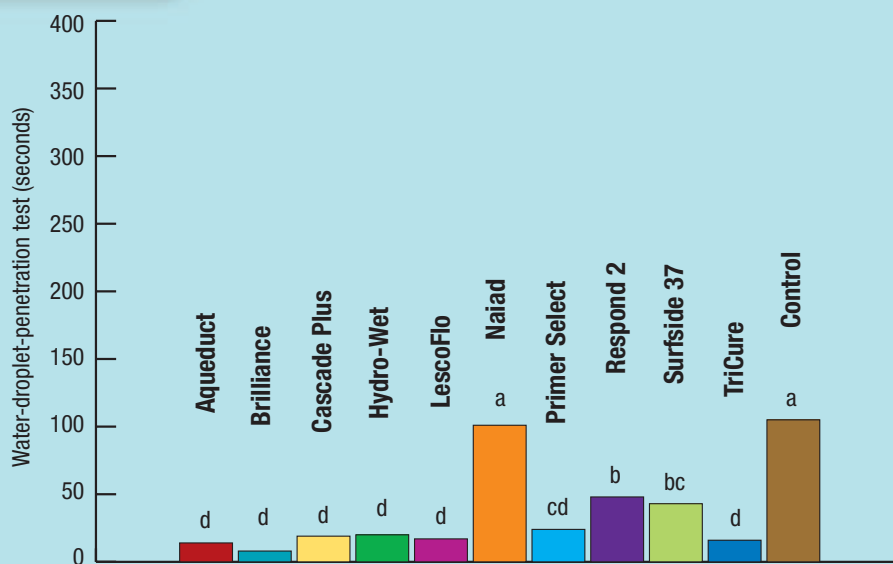


Figure 5. Overall average water-droplet-penetration times (WDPT) in seconds for samples taken at a depth of 0.5 centimeter (0.2 inch) across all sampling dates in 2003. Means with the same letter are not significantly different.

WDPT, 2004

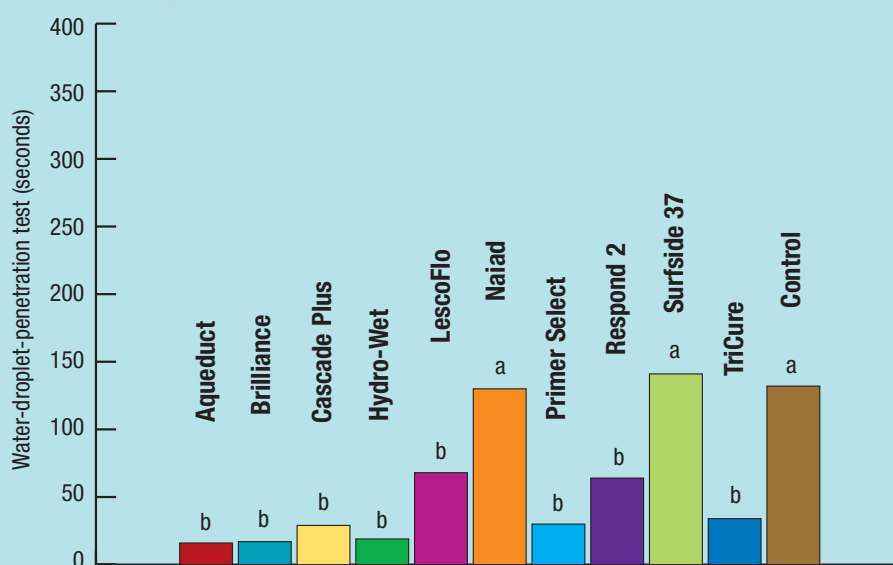


Figure 6. Overall average WDPT (seconds) for samples taken at a depth of 0.5 centimeter (0.2 inch) across all sampling dates in 2004. Means with the same letter are not significantly different.

DISCUSSION

In western Washington, localized dry spot symptoms may not be as severe as in other parts of the country, where temperatures are higher. Severe LDS is rare, but superintendents often apply wetting agents to improve turf uniformity because of their possible impact on the nonuniform moisture dynamics of soil. In this evaluation, Cascade Plus, Hydro-Wet, LescoFlo and TriCure improved uniformity and therefore quality.

Naiad and Surfside 37 were mostly ineffective in improving water-droplet-penetration time (WDPT) at our site. For the other products, effects on soil hydrophobicity were limited to the upper 0.5 centimeter (0.2 inch) of the sand profile. Because WDPT was usually highest at the 2.5-centimeter (1-inch) depth (averaging 363 seconds in 2003, but often over the 600-second maximum), we increased post-application irrigation from 0.1 inch (0.25 centimeter) to 0.25 inch (0.64 centimeter) in 2004 to move the products deeper into the profile. The increased irrigation did not appear to have an impact, because WDPT below 0.5 centimeter (0.2 inch) was not significantly affected by wetting agent application in 2004.

SUMMARY

- There were no statistically significant differences in annual quality means as a result of wetting agent application in either year.
- Cascade Plus, Hydro-Wet, LescoFlo and TriCure resulted in quality ratings that were numerically higher than the control in both years. Plots treated with these products generally had a more uniform appearance.
- Wetting agents affected WDPT only at the 0.5-centimeter (0.2-inch) depth.
- In 2003, all products except Naiad significantly reduced WDPT at the 0.5-centimeter (0.2-inch) depth compared to the control. Aqueduct, Brilliance, Cascade Plus, Hydro-Wet, LescoFlo and TriCure were most effective. Primer Select, Respond 2 and Surfside 37 were intermediate in their effectiveness.
- In 2004, all products except Naiad and Surfside 37 significantly decreased WDPT at the 0.5-centimeter (0.2-inch) depth compared to the untreated control.
- No phytotoxicity data are shown, but Cascade Plus resulted in moderate phytotoxicity for two weeks following the first application in both years (May 27, 2003; May 18, 2004), and for three days following the second application in 2003 (June 6) and one week in 2004 (May 28).
- Hydro-Wet resulted in moderate phytotoxicity for 10 days following the third application in 2004 (Aug. 10).
- Brilliance resulted in moderate phytotoxicity for 10 days following the third application in 2004 (Aug. 20).

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