Selecting zoysiagrass cultivars: Turf quality and stress tolerance

Improve turf performance and environmental stress tolerance through proper cultivar selection.

Editor's note: This article is the first of a two-part series describing differences among zoysiagrass cultivars. In the June 2010 issue of GCM, the author will present information on the pest tolerance of zoysiagrass cultivars and other selection criteria to examine when choosing the best zoysiagrass cultivar(s) for your golf course.

Zoysiagrass (Zoysia spp. Willd.) has been slowly increasing in use across the U.S. since it was first introduced around 1900. Japanese lawngrass (Zoysia japonica Steud.) and Manilagrass (Z. matrella (L.) Merr.) are the most commonly used species, and in the U.S., both are commonly referred to as zoysiagrass. Zoysia matrella has a narrower leaf than Z. japonica, and Z. matrella typically grows more slowly and is less cold-hardy, but is more tolerant to salinity and insect pests.

Zoysiagrass in the U.S.

The first zoysiagrass cultivar in the U.S., Matrella (FC 13521), was released in Alabama in the early 1940s. Zoysiagrass was immediately popular in the southern U.S. because few weel-adapted species and cultivars were available for lawns. The release of Matrella was closely followed by the release of Meyer, Sunburst and Emerald (Z. japonica x Z. pacifica) in the 1950s (Table 1). Meyer and Emerald quickly became industry standards for zoysiagrass, but many other zoysiagrass cultivars did not become commercially available until the 1980s (Table 1, Figure 1).

By 2006, approximately 16,293 acres (6,593.5 hectares) of zoysiagrass had been planted on golf courses in the U.S., with 81% in the transition zone and 18% in the southeastern U.S. (4). Although the majority of zoysiagrass is used in the transition zone, the availability of more cultivars, especially those that perform well in warmer regions, has led to increased use in the southeastern U.S. (Figure 1). Of the 38 zoysiagrass cultivars currently or previously used in the U.S., 32 were commercially available in 2009 (Table 1). Twenty-nine were released after 1980, 24 were released after 1990, and 15 were released after 2000 (Figure 1). (Table 1 includes 38 cultivars, but only 37 are included in Figure 1. Chinese common seeded zoysiagrass is missing from the count in Figure 1 because it is not clear when it was first sold in the U.S.)

A great deal of research on zoysiagrass has taken place since 1990. Various environmental stresses (cold temperature and drought tolerance, divot recovery, salinity tolerance, shade tolerance) and various biotic stresses (insect resistance, mite resistance, disease resistance, nematode resistance) have been studied for many commonly used zoysiagrass cultivars. Zoysiagrass growth characteristics have also been studied, including rooting, stolon growth, establishment and clipping yield. Additionally, zoysiagrass turf quality, color, density and texture have been documented by previous and current trials through the National Turfgrass Evaluation Program (NTEP, www.ntep.org).
Despite the large body of literature on zoysiagrass, this information remains largely unavailable to superintendents. Often, cultivar selection is based solely on local availability of sod, and many well-adapted cultivars are not planted in certain environments because of their limited availability. Because many cultivars are available and information about them is difficult to obtain, I have written this two-part series to assist superintendents in selecting the right zoysiagrass cultivars.

**Zoysiagrass quality**

Turf quality varies by region for each turfgrass species. Specifically, zoysiagrass turf quality is influenced mostly by differences in texture and density between species: *Z. japonica* has a coarser leaf texture and less density than *Z. matrella*. Stress tolerance is the other key factor that separates the turf quality of zoysiagrass cultivars.

For example, Meyer has excellent winter hardness and thus often performs well in the transition zone and is ranked in the top half of the cultivars in each of the years tested for turf quality in areas with cold winters (Table 2). However, because Meyer has poor drought and pest tolerance, it does not perform well farther south and is ranked near the bottom in turf quality when zoysiagrasses are tested in the southern U.S. Some cultivars like Emerald, Zorro, Cavalier, Himeno, Marquis and Zeon have good turf quality in both the southern U.S. and in the southern and central areas of the transition zone. Other cultivars such

---

**Zoysiagrass cultivars**

| Name | Experimental no. | Type | Species | Breeder or supplier | Year
|------|------------------|------|---------|---------------------|------
| Belair | AN R52-25 | veg | *Z. japonica* | USDA | 1987
| BK-7 | | veg | *Z. japonica* | Craft Turf Farms, Foley, AL | 1987
| Camelot | 6136 | veg | *Z. japonica* | Blackrumber Farms, Poteet, TX | 2006
| Cashmere | F-1 | veg | *Z. matrella* | Purley Turf Farms, Palmers, FL | 1996
| Cavalier | DALZ 6507 | veg | *Z. matrella* | Texas A&M Univ., Dallas | 1996
| Chinese Common | | seeded | *Z. japonica* | | 2000
| Compade | ZMB-2 | seeded | *Z. japonica* | Seed Research of Oregon, Corvallis | 1996
| Crowne | DALZ 6512 | veg | *Z. japonica* | Texas A&M Univ., Dallas | 1996
| Dalanza | Z88-8 | veg | *Z. japonica* | West Coast Turf, Stevenson, CA | 1996
| Diamond | DALZ 6502 | veg | *Z. japonica* | Texas A&M Univ., Dallas | 1996
| El Taro | UCRM11 | veg | *Z. japonica* | U.S. Dep of Agriculture, Riverside | 1996
| Emerald | 34-35 | veg | *Z. japonica x Z. palustris* | USDA | 1995
| Empress | SS-300 | veg | *Z. japonica* | Sod Solutions, Mt. Pleasant, SC | 1996
| Empriss | SS-350 | veg | *Z. japonica* | Sod Solutions, Mt. Pleasant, SC | 1996
| GN-2 | ZT-11 | veg | *Z. japonica* | Greg Norman Turf, Naples, FL | 1999
| Himeno | | veg | *Z. japonica* | Winkock Grass Farm, Little Rock, AR | 2002
| JaMii | | veg | *Z. japonica* | Blackrumber Farms, Poteet, TX | 2002
| Marlin | | veg | *Z. japonica* | Heritage Turf, Midway, CA | 2002
| Marquis | TC 2033 | veg | Zoysia species | Turf Centre, Spencerville, MD | 2002
| Matrella | FC-12621 | veg | *Z. matrella* | Alabama Agric. Experiment Station | 1941
| Meyer | Z-32 | veg | *Z. japonica* | USDA | 1951
| Midwest | | veg | *Z. japonica* | Indiana Agricultural Experiment Station | 1963
| Omni | CD 2013 | veg | *Z. matrella* | Blackrumber Farms, Poteet, TX | 1996
| Palisades | DALZ 6514 | veg | *Z. japonica* | Texas A&M Univ., Dallas | 1996
| Pristine | | veg | *Z. matrella* | U.S. Dep of Agriculture, Riverside | 2005
| Rollmaster | | veg | *Z. matrella* | Winkock Grass Farm, Little Rock, AR | 2006
| Royal | DALZ 9006 | veg | *Z. matrella* | Texas A&M Univ., Dallas | 2001
| Senator | | veg | *Z. matrella* | Heritage Turf, Midway, CA | 2002
| Shadowknot | | veg | *Z. matrella* | Key Gardens Greenhouses, Lubbock, TX | 2007
| Southern Gem | | veg | *Z. japonica* | Heritage Turf, Midway, CA | 2008
| Sunburst | Z-73 | veg | *Z. japonica* | U.S. Dep of Agriculture, Riverside | 1952
| Ultimate | | veg | *Z. japonica* | U.S. Dep of Agriculture, Riverside | 2005
| Victoria | Z88-14 | veg | *Z. japonica* | West Coast Turf, Stevenson, CA | 1995
| Yad | | veg | *Z. japonica* | Blackrumber Farms, Poteet, TX | 2006
| Zenith | ZNW-1 | seeded | *Z. japonica* | Patten Seed, Lakeeland, FL | 2000
| Zeon | | veg | *Z. japonica* | Blackrumber Farms, Poteet, TX | 1996
| Zoro | DALZ 6301/6601 | veg | *Z. japonica* | Texas A&M Univ., Dallas | 2001
| ZoyBoy | Z-3 | veg | *Z. japonica* | Quality Turfgrass Marketing, Dallas, TX | 1994

1. Type of establishment (propagation) method typically used by practitioners for each cultivar. Genotypes available by seed are typically needed, with other genotypes typically established vegetatively (veg) by sprigs, plugs or sod.
2. Year released or made available to public.
3. The cultivar was commercially available in the U.S. in 2009.

**Table 1.** Cultivar name, experimental designation, propagation type, species, breeder or supplier, and release date for zoysiagrass cultivars used across the U.S.
as Crowne, GN-Z, Palisades, Royal and Victoria have better turf quality in the southern U.S. than in the transition zone.

A large group of commercially available cultivars has never been entered into NTEP trials, including BK-7, Carrizo, Cashmere, Empire, Empress, Marion, Mattrela, Midwest, PristineFlora, Rollmaster, Serene, Southern Gem, UltimateFlora, Y2 and ZoYBoy. Information about the turf quality of these cultivars is lacking or often limited to locally available anecdotal observations. Some of these cultivars — Carrizo, Marion, PristineFlora, Rollmaster, Serene, Shadowturf, Southern Gem, Y2 and UltimateFlora — have been released since 2005, and information is lacking because of their recent release. Shadowturf, released in 2007, is included in the 2007 zoysiagrass NTEP trial along with the standards Zenith, Meyer and Zorro.

**Turf color**

Turf color is likely to have little influence on the selection of a zoysiagrass cultivar for golf course use because zoysiagrass color (both summer and winter) contrasts well with the color of other species such as tall fescue (*Festuca arundinacea* Schreb.), or bermudagrass (*Cynodon dactylon* [L.] Rich.), which are often used for golf course roughs in the transition zone and the southern U.S. Other factors such as pest resistance, stress tolerance and turf quality are more important and should be weighted as such. However, color could be a decisive factor in the decision between two cultivars with otherwise similar qualities.

Turf color was darkest green for Belair, Emerald, Marquis, Meyer and Royal in the 1991 NTEP trial; Meyer, Emerald and Zenith in the 1996 NTEP trial; and Emerald, Himeno and Meyer in the 2002 NTEP trial (www.ntep.org) (Table 2). Since color data are only available from NTEP trials, turf color data are lacking for a large group of cultivars.

**Leaf texture**

Zoysia japonica has wider leaves (>2 millimeters) than Z. matrella (<2 millimeters). Belair, Chinese Common, Compadre, DeAnza, Diamond, Emerald, Himeno, Shadowturf, Southern Gem, Y2 and Y2K have better turf quality in the southern U.S. than in the transition zone.

### Quality rankings, color and texture ratings

<table>
<thead>
<tr>
<th>Table 2. Turfgrass quality rankings, and genetic color and leaf texture ratings for zoysiagrass cultivars entered into NTEP trials in 1991, 1996, or 2002. Rankings are given separately for the transition zone and the Southern U.S., 1 = best ranked cultivar.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
</tr>
<tr>
<td><strong>Year/cultivar</strong></td>
</tr>
<tr>
<td>Belair*</td>
</tr>
<tr>
<td>Cavalier*</td>
</tr>
<tr>
<td>Chinese Common</td>
</tr>
<tr>
<td>Compadre*</td>
</tr>
<tr>
<td>Crowne*</td>
</tr>
<tr>
<td>DeAnza*</td>
</tr>
<tr>
<td>Diamond*</td>
</tr>
<tr>
<td>Emerald*</td>
</tr>
<tr>
<td>GN-Z*</td>
</tr>
<tr>
<td>Himeno*</td>
</tr>
<tr>
<td>J&amp;M*</td>
</tr>
<tr>
<td>Marquis</td>
</tr>
<tr>
<td>Meyer*</td>
</tr>
<tr>
<td>Ozark</td>
</tr>
<tr>
<td>Palisades</td>
</tr>
<tr>
<td>Royal*</td>
</tr>
<tr>
<td>Southwind</td>
</tr>
<tr>
<td>Victoria</td>
</tr>
<tr>
<td>Zenith*</td>
</tr>
<tr>
<td>Zoro*</td>
</tr>
</tbody>
</table>

---

*Turf quality rankings are based on turfgrass color, density, uniformity, texture, and susceptibility to disease or environmental stress. Some of these cultivars are not commercially available, and information is lacking because of their recent release. Shadowturf, released in 2007, is included in the 2007 zoysiagrass NTEP trial along with the standards Zenith, Meyer and Zorro. **Leaf texture** Zoysia japonica has wider leaves (>2 millimeters) than Z. matrella (<2 millimeters). Belair, Chinese Common, Compadre, DeAnza, Diamond, Emerald, Himeno, Shadowturf, Southern Gem, Y2 and Y2K have better turf quality in the southern U.S. than in the transition zone.
Chinese Common, Compadre, Crowne, El Toro, Empire, Himeno, JaMur, Palisades, Sunburst and Zenith are among the zoysiagrass cultivars with the coarsest texture (widest leaves) based on published reports (Table 2). Cavalier, Diamond, Emerald, Royal, Zenon and Zorro are among the narrowest-leaved cultivars (Table 2). Carrizo, DeAnza, Empress, GN-Z, Meyer, Y2 and Victoria are among a group with intermediate leaf texture (www.ntep.org). The leaf texture of other cultivars is not reported in the literature, but Cashmere, Matrella, PristineFlora, Rollmaster and Shadowturf are fine-textured; Marion, Marquis, Serene, Southern Gem and UltimateFlora have intermediate leaf texture; and Midwest and Empire have coarse texture. Among all the cultivars, Diamond, PristineFlora and Cashmere have the finest texture.

Many commercially available Z. japonica cultivars are not a single species as classified by their leaf texture, but instead are interspecific hybrids. Cultivars such as Victoria, El Toro and Palisades are likely crosses of Z. japonica and Z. matrella, but are classified as Z. japonica because of their morphology. Other cultivars such as Empress, GN-Z and DeAnza are also likely interspecific hybrids because of their intermediate leaf texture.

Environmental stress tolerance

Drought tolerance and water use are becoming increasingly important in the U.S. in light of increased urbanization, recent droughts, water shortages and water restrictions. Zoysiagrass is generally classified as being less drought resistant than bermudagrass, but zoysiagrass cultivars differ in irrigation requirement, rooting depth and leaf firing.

Irrigation requirement

Researchers in Dallas studied the amount of irrigation required to prevent water stress (wiling) (11). In addition to an average annual rainfall of 44 inches (1,118 millimeters), El Toro, Palisades and Crowne required the least supplemental irrigation (<5.9 inches [<149 millimeters]); Meyer required 11.1 inches (282 millimeters) of supplemental irrigation; and Diamond, Matrella, Emerald, Zorro, Cashmere and Cavalier required the most supplemental irrigation (>14.2 inches >360 millimeters) (Table 3) (11).

Rooting depth

Plants are known to tolerate drought by enhancing water uptake through increased rooting depth, which prolongs the need for supplemental irrigation. Using root tubes and controlled growing conditions, researchers documented (5) that Belair, Crowne, El Toro, Emerald, Marquis, Meyer and Palisades were among the cultivars with the highest average maximum rooting depth (>11.6 inches >295 millimeters), while Cavalier, Diamond, Royal and Sunburst had the lowest (<10.1 inches <256 millimeters) (Table 3). They also found that the average maximum rooting depth was related to survival under severe (0% ET) and moderate (35% ET) drought stress (5), indicating that zoysiagrasses tolerate drought by maintaining high tissue water potential through deep rooting.

Leaf firing

Turfgrass has a number of functional roles including evaporative cooling, air pollution mitigation and athlete safety, among others. However, drought minimizes the ability of turf to maintain these functions. One common method that is used to measure interspecific differences in response to drought is leaf firing (green turf color retention).

Meyer was found to have high leaf firing (>50%) or low green-color retention during drought in College Station, Texas; El Toro, Emerald, Matrella and Marquis had low leaf firing (<10%) or high green-color retention during drought (Table 3) (3). A follow-up field study reported that Matrella and Diamond had less than 20% leaf firing when data were averaged across three dates (60, 90 and 120 days of drought stress) in College Station (1), while Belair, El Toro and Meyer had more than 40% leaf firing during the same period.

More recently, drought tolerance was evaluated in San Antonio, Texas (2). Leaf firing after 20 days of drought in 2006 was lowest among Cavalier, El Toro, Emerald, Empire, JaMur, Palisades and Zenon and highest among Y2 and Zorro. Leaf firing after 30 days of drought in 2007 was lowest among Cavalier, El Toro, Emerald, Empire, JaMur, Palisades and Victoria, El Toro, Empire, JaMur, Palisades and Zorro were among the cultivars with the finest texture.

More information on zoysiagrass cultivars

Readers may want to refer to previously published GCM articles that describe differences in zoysiagrass cultivars.


Table 3. Environmental stress tolerance of zoysiagrass cultivars commonly grown in the U.S. Only cultivars tested in research trials are included in this table.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Irrigation needed (mm)*</th>
<th>Avg. max. root depth (mm)*</th>
<th>Drought response (leaf firing) 1985 1988 2006 2007</th>
<th>Salinity response (% leaf firing) Study A Study 1 Study 2</th>
<th>Cumulative TPI under 90% shade††</th>
<th>Shade tolerance rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bellair</td>
<td>440 ab</td>
<td>296 abc</td>
<td>4.5 abc 5.8 abc 37.9 cd 48.3 a 40.7 a 28 G</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>Correa</td>
<td>300 ab</td>
<td>255 b-e</td>
<td>4.5 abc 5.8 abc 37.9 cd 48.3 a 40.7 a 28 G</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>Cashmere</td>
<td>300 ab</td>
<td>255 b-e</td>
<td>4.5 abc 5.8 abc 37.9 cd 48.3 a 40.7 a 28 G</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>Crowne</td>
<td>90 d</td>
<td>355 a</td>
<td>4.5 abc 5.8 abc 37.9 cd 48.3 a 40.7 a 28 G</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>Dalanita</td>
<td>148 cd</td>
<td>366 a</td>
<td>6.5 a 8.0 a 37.9 cd 33.6 cd 40.1 a 31 P</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>Diamond</td>
<td>488 a</td>
<td>246 cd</td>
<td>5.3 ab 6.8 abc 33.6 cd 40.1 a 31 P</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>Emerald</td>
<td>437 ab</td>
<td>333 ab</td>
<td>5.3 ab 6.8 abc 33.6 cd 40.1 a 31 P</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>Empire</td>
<td>488 a</td>
<td>246 cd</td>
<td>5.3 ab 6.8 abc 33.6 cd 40.1 a 31 P</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>JaMur</td>
<td>282 bc</td>
<td>333 ab</td>
<td>5.3 ab 6.8 abc 33.6 cd 40.1 a 31 P</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>Marquis</td>
<td>300 abc</td>
<td>33.6 d</td>
<td>33.6 d 30.5 de 16.0 cd</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>Matrella</td>
<td>457 a</td>
<td>19</td>
<td>33.6 cd 33.6 cd 33.6 cd 33.6 cd 33.6 cd 31 P</td>
<td></td>
<td>45.4 abc 16 16 16 16</td>
<td></td>
</tr>
<tr>
<td>Meyer</td>
<td>282 bc</td>
<td>333 ab</td>
<td>54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a</td>
<td>45.1 ab 22.5 b 16 P</td>
<td>50.0 ab 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc</td>
<td>50%</td>
</tr>
<tr>
<td>Omni</td>
<td>637 a 318 ab</td>
<td>42</td>
<td>54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a</td>
<td>45.1 ab 22.5 b 16 P</td>
<td>50.0 ab 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc</td>
<td>50%</td>
</tr>
<tr>
<td>Palisades</td>
<td>132 cd 318 ab</td>
<td>42</td>
<td>54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a</td>
<td>45.1 ab 22.5 b 16 P</td>
<td>50.0 ab 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc</td>
<td>50%</td>
</tr>
<tr>
<td>Royal</td>
<td>177 e</td>
<td>33.6 e</td>
<td>54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a</td>
<td>45.1 ab 22.5 b 16 P</td>
<td>50.0 ab 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc</td>
<td>50%</td>
</tr>
<tr>
<td>Sunburst</td>
<td>203 de</td>
<td>20.0 e</td>
<td>54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a</td>
<td>45.1 ab 22.5 b 16 P</td>
<td>50.0 ab 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc</td>
<td>50%</td>
</tr>
<tr>
<td>Victoria</td>
<td>203 de</td>
<td>20.0 e</td>
<td>54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a</td>
<td>45.1 ab 22.5 b 16 P</td>
<td>50.0 ab 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc</td>
<td>50%</td>
</tr>
<tr>
<td>Y2</td>
<td>3.0 cd</td>
<td>5.8 abc</td>
<td>54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a</td>
<td>45.1 ab 22.5 b 16 P</td>
<td>50.0 ab 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc</td>
<td>50%</td>
</tr>
<tr>
<td>Zealit</td>
<td>500 ab</td>
<td>5.5 bc</td>
<td>54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a</td>
<td>45.1 ab 22.5 b 16 P</td>
<td>50.0 ab 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc</td>
<td>50%</td>
</tr>
<tr>
<td>Zonos</td>
<td>390 ab</td>
<td>5.3 cd 5.3 c</td>
<td>54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a 54.3 a</td>
<td>45.1 ab 22.5 b 16 P</td>
<td>50.0 ab 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc 7.0 abc</td>
<td>50%</td>
</tr>
</tbody>
</table>

*From White et al. (11). Supplemental irrigation requirement to prevent wilting. Mean of three years (1989-1991) in Dallas, Texas, with an average annual rainfall of 44.0 inches (1,118 millimeters).
†From Marcum et al. (9).
‡From Kim et al. (3). Leaf firing after 20 days of drought in 1985 in College Station, Texas. Values indicate salinity tolerance.
§From Chalmers et al. (2). Leaf firing after 20 days of drought in 2006 and 30 days of drought in 2007 in San Antonio, Texas. High values indicate drought tolerance; 9 = no leaf firing.
¶From Marcum et al. (5).
∥From White et al. (11). Supplemental irrigation requirement to prevent wilting. Mean of three years (1989-1991) in Dallas, Texas, with an average annual rainfall of 44.0 inches (1,118 millimeters).

Table 3. Environmental stress tolerance of zoysiagrass cultivars commonly grown in the U.S. Only cultivars tested in research trials are included in this table.

and Y2. As illustrated by these reports, choosing a drought-tolerant cultivar will help reduce water use while simultaneously improving turfgrass performance and aesthetic quality.

**Salinity tolerance**

With freshwater sources for turfgrass irrigation becoming more limited, the use of low-quality recycled water sources is becoming more common. Zoysiagrass is classified as moderately tolerant to salinity stress, but there are significant differences among cultivars. Similar to drought tolerance, leaf-firing measurements (green turf color retention) are often used as a measurement of salinity tolerance. Researchers have reported that Z. matrella cultivars were more tolerant to salinity than Z. japonica cultivars (6). Among cultivars, Diamond is the most tolerant to salinity; Crowne, Dalanita, El Toro, Emerald, JaMur, Marquis, Palisades, Royal and Victoria have intermediate salinity tolerance; and Bellair, Cavalier, Meyer, Omni, Sunburst and Zonos are the least tolerant to salinity (6,7) (Table 3).

**Shade tolerance**

Another common environmental stress of turfgrass is shade. Zoysiagrasses are generally considered to have good shade tolerance. The most com-

Literature cited

The research says

In 2009, 32 zoysiagrass cultivars were commercially available and more than 16,293 acres of zoysiagrass were planted on U.S. golf courses.

Although the majority of zoysiagrass is used in the transition zone, its use is increasing in the southeastern U.S. with the increased availability of cultivars, especially those that perform well in warmer regions.

Zoysiagrasses vary in their turf quality, adaptability, shade tolerance, drought and salinity tolerance.

Before purchasing and planting a cultivar, superintendents should vet zoysiagrass cultivars by interviewing and visiting others who are currently growing the same cultivar in their region.

Acknowledgments
Thanks to the following researchers for reviewing the full version of this manuscript and making helpful suggestions for its improvement: Mike Richardson, University of Arkansas; Kevin Kenworthy, University of Florida; and James Reinert, Texas A&M System, Agri-Life Research and Extension Urban Solutions Center at Dallas.

Aaron Patton (ajo patterton@uark.edu) is an assistant professor and turfgrass Extension specialist at the University of Arkansas.

Overview
Each region or site-specific location has different requirements, and the preferences of superintendents vary. However, some cultivars in each region perform well because of their quality and tolerance to one or more abiotic stresses. Select a well-adapted cultivar that is also regionally or locally available.

This two-part series is intended to help superintendents assemble information to select the best zoysiagrass cultivars for their particular location. As new data become available, use them in conjunction with this publication to aid in cultivar selection. Before purchasing and planting a cultivar, superintendents, regardless of their location, should vet that cultivar by interviewing and visiting others currently growing the cultivar in their region.


Literature cited

The research says

In 2009, 32 zoysiagrass cultivars were commercially available and more than 16,293 acres of zoysiagrass were planted on U.S. golf courses.

Although the majority of zoysiagrass is used in the transition zone, its use is increasing in the southeastern U.S. with the increased availability of cultivars, especially those that perform well in warmer regions.

Zoysiagrasses vary in their turf quality, adaptability, shade, drought and salinity tolerance.

Before purchasing and planting a cultivar, superintendents should vet zoysiagrass cultivars by interviewing and visiting others who are currently growing the same cultivar in their region.

Acknowledgments
Thanks to the following researchers for reviewing the full version of this manuscript and making helpful suggestions for its improvement: Mike Richardson, University of Arkansas; Kevin Kenworthy, University of Florida; and James Reinert, Texas A&M System, Agri-Life Research and Extension Urban Solutions Center at Dallas.

Aaron Patton (ajo patterton@uark.edu) is an assistant professor and turfgrass Extension specialist at the University of Arkansas.