MP476

Establishing Seeded Zoysiagrass on Lawns and Golf Courses

UofA
UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE

University of Arkansas, United States Department of Agriculture,
and County Governments Cooperating

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Introduction

Zoysiagrass (*Zoysia japonica*) is a warm-season turfgrass species that provides an excellent golfing surface in Arkansas that can be used for tees, fairways, roughs and bunker faces. Established zoysiagrass creates a uniform, dense, low-growing, high-quality turf with excellent heat, drought, pest and wear tolerance. Zoysiagrass was first introduced by seed in the U.S. around 1900 but was not used in Arkansas until the 1950s, when the cultivar Meyer was released. Meyer zoysiagrass gained immediate popularity because of its heat, freeze and drought tolerance in Arkansas. Meyer can only be established vegetatively because its seed does not produce plants with the same texture, vigor and freeze tolerance (7). Establishing zoysiagrass by strip-sodding, sprigging or plugging is less expensive than solid-sodding, but these methods may require two or more years to achieve full establishment (23). As a result, the high cost of vegetative establishment and a slow establishment rate compared to bermudagrass have limited more widespread use of zoysiagrass. Several improved vegetative cultivars of zoysiagrass were recently released, but Meyer remains the most widely used and most available cultivar in Arkansas.

Historically, seeded zoysiagrass had limited use because of poor turf quality, germination rates and seed production (26,30). Korean common and Chinese common are two seeded varieties harvested from native stands in Korea or China that have been available for many years. However, these varieties have a coarse leaf texture and produce lower-quality turfs compared to Meyer (13,14). Additionally, zoysiagrass seed has a dormancy factor that results in low germination rates. Treatments to overcome seed dormancy were discovered in the 1980s (23,31,32). The germination rate of untreated dormant zoysiagrass seed is < 10 percent, while seed chemically scarified with potassium hydroxide has germination rates as high as 90 percent (23). A final problem limiting zoysiagrass establishment by seed and the number of cultivars released is low seed yields (~100 lb/acre) of experimental cultivars (26). However, the cultivars Zenith and Compadre (formerly Companion) can be established by seed and are now commercially available (Fig. 1). Their turf quality in Arkansas is slightly less than Meyer (18), but both are well-adapted to Arkansas and have excellent cold tolerance (15).

Fig. 1. 'Zenith' zoysiagrass seed.

Seeded zoysiagrass has tremendous potential for lawn and golf course use because it affords the benefits of vegetatively established zoysiagrass but can be established at a fraction of the cost of sodded zoysiagrass. Today, all commercially available zoysiagrass seeds are chemically scarified to improve germination rates and the feasibility of using seed on a large scale. However, there is a limited body of information regarding establishing zoysiagrass from seed. This publication summarizes recent research in the transition zone (inclusive of Arkansas) on establishing zoysiagrass by seed and can be used as a guide by practitioners wishing to establish seeded zoysiagrass.

Site Preparation

There are two practical scenarios for establishing seeded zoysiagrass in Arkansas. The first scenario is planting on bare soil where there is no existing vegetation to remove prior to establishment. This is usually the case during the construction of a new golf course or teeing ground. A second scenario is preparation of a seedbed in an established bermudagrass turf. Regardless of establishment scenario, it is important to correct nutrient deficiencies and modify soil pH as well as correct drainage problems prior to establishment. Soil pH should be adjusted above 5.0 prior to planting, with 5.8 to 6.5 being preferred. More information on soil testing and liming is available in publication FSA6134, *Liming Your Lawn*.

Before seeding into bare or fallow ground, perennial grassy weeds should be controlled with Roundup (glyphosate) prior to tilling, since there are few selective herbicides that control perennial grassy weeds in zoysiagrass with a single application. Maximize seed-to-soil contact after seeding, but do not bury the seeds deeper than 1/4 inch deep, since zoysiagrass seed requires light to germinate (5). Zoysiagrass establishes most quickly when the soil is tilled prior to seeding and can produce 100 percent cover by the end of the growing season when there is no weed pressure (Fig. 2) (17).

The second scenario for establishing seeded zoysiagrass is conversion from existing bermudagrass. Converting an existing common bermudagrass turf to seeded zoysiagrass is difficult. Fumigation with methyl bromide or dazomet is the best option for removing existing bermudagrass prior to seeding (30), but this option is not available to some and is expensive. If fumigation is not an option, three applications of Roundup over the growing season (May, June and August) will adequately control pre-existing bermudagrass (9). Additional research has shown that tank mixing Roundup with Fusilade (fluazifop) will improve bermudagrass control over glyphosate alone, but two to three applications are still necessary for adequate control (2,28). Treated areas should be allowed to regrow from stolons and rhizomes before making the sequential applications. Fusilade has residual soil activity, so seeding should be delayed for 30 days after application. This process will require most of the growing season and will require an additional growing season for conversion.

Seeding Date

Late spring to early summer is the preferred seeding date for warm-season grasses (8). Zoysiagrass can be seeded when soil surface temperatures first reach 68° to 72° F (4,24). This timing allows for the longest period of warm temperatures necessary to adequately establish zoysiagrass before winter (1). Germination typically occurs 10 or more days after seeding but may occur in as little as 7 days under optimum soil moisture and temperature. Due to the slow establishment of zoysiagrass, the seeding window for acceptable establishment is narrow. Korean common zoysiagrass seeded on June 18 or July 1 in southern Illinois provided up to 90 percent coverage by October (23). Seeding Zenith zoysiagrass in June in Kansas produced 75 percent or more coverage before winter (33). Zenith seeded between

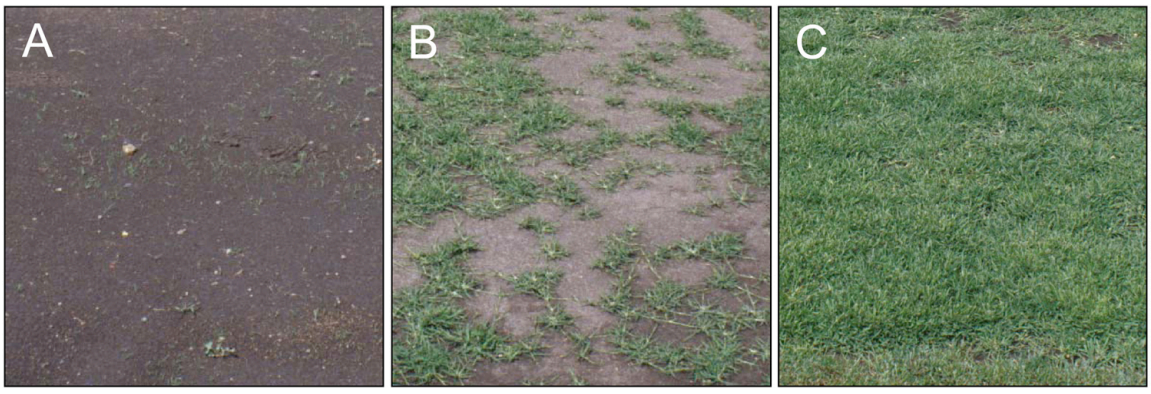

Fig. 2. 'Zenith' zoysiagrass established in a seedbed that was tilled and fumigated with methyl bromide prior to seeding. Zoysiagrass coverage 15 days after seeding (A), 45 days after seeding (B) and 90 days after seeding (C).

June 1 and 15 in Indiana and June 1 and July 1 in Kentucky produced 90 percent or more coverage by October (17). Dormant seedings of zoysiagrass in Arkansas in the months of February and March have been largely unsuccessful. Zoysiagrass can be seeded in April in Arkansas, but germination and establishment will be slow until temperatures increase in May and June.

Overall, data suggest that the seeding window for zoysiagrass in Arkansas is May 15 to July 1. It is important to seed as early as possible within this window to allow ample time for the stand to mature in case of weed competition, drought or cooler-than-average temperatures, all of which will reduce establishment rates. Seeding zoysiagrass before May 15 could reduce initial germination and establishment rates due to cooler air and soil temperatures and could increase competition from germinating annual bluegrass (*Poa annua*) during cool, wet springs. Seeding zoysiagrass too late in summer reduces coverage prior to winter but has little effect on winter injury, as seeded zoysiagrasses are very cold hardy.

Seeding Rate

For rapid establishment, 1.0 to 2.0 lb pure live seed (PLS) per 1,000 ft^2 are recommended, whereas 0.5 lb PLS per 1,000 ft^2 is recommended to reduce cost in areas where rapid coverage is not required (Fig. 3) (17). By definition, pure live seed is determined by multiplying the germination percentage by the percent purity of the seed lot. Additional zoysiagrass research demonstrated that coverage after one growing season was increased by a maximum of 11 percent when seeding rates were increased from 1.0 to 2.0 lb PLS per 1,000 ft^2 (21). However, the estimated cost of increasing the seeding rate from 1.0 to 2.0 lb PLS per 1,000 ft^2 is $900/acre, which raises the question of whether the improvement in zoysiagrass coverage is economically justified by increasing the rate above 1.0 PLS per 1,000 ft^2 (21).

Seed Covers

Covers are often used on northern golf courses to protect greens during the winter, but they can also be used for soil warming. It is known that zoysiagrass germination increases as temperatures rise, with maximum germination occurring between 86° to 95° F (23,35). The first report of using covers to establish zoysiagrass was in 1967. Early work in this area found that clear polyethylene plastic was useful for establishing zoysiagrass from seed (24,33). Although soil surface temperatures rose as high as 133° F under these covers, zoysiagrass germination is not inhibited until soil temperatures exceed 140° F (24). However, seedlings can be killed or injured at temperatures above 122° F, indicating that the timing of polyethylene cover removal is important (11). These studies indicate that polyethylene covers can be used to increase germination and early establishment without damaging seedlings if removed no later than two weeks after seeding. Other materials tested, such as

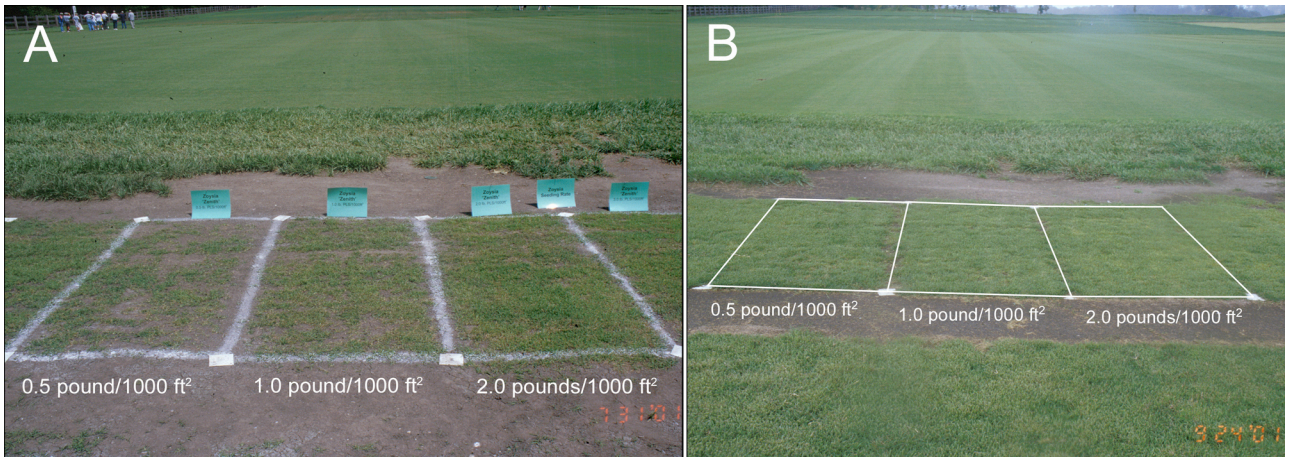

Fig. 3. 'Zenith' zoysiagrass established at different seeding rates in a seedbed that was tilled and fumigated with methyl bromide prior to seeding. Zoysiagrass establishment 39 (A) and 94 (B) days after seeding when seeded at 0.5, 1.0 and 2.0 lb pure live seed per 1,000 ft^2.

straw (80 lb/1,000 ft^2), did not enhance germination because they excluded light and reduced soil temperatures (24). A study in Arkansas was initiated to determine how various seed covers influence the germination and establishment of zoysiagrass. Clear polyethylene cover (4 mil, 0.1 mm), Curlex, Deluxe (0.5 oz crop protection fabric), Futerra F4 Netless, Futerra original, Jute, Poly Jute, straw, Straw blanket and Thermal blanket (3 oz) were used as cover treatments. Zoysiagrass coverage was similar for all cover treatments except for straw-covered plots, which had significantly lower coverage. Many cover technologies can be used to successfully establish zoysiagrass (20) (Table 1). Seed germination blankets allow light penetration and gas exchange, facilitate soil warming, increase soil moisture-holding capacity and can be used without the risk of excessive temperature buildup. All temporary covers should be removed two weeks after seeding to increase germination without risking injury to seedlings. Uncovered plots performed well in 2008 and poorly in 2007 (data not shown), suggesting that seed covers are not always needed for successful establishment but they are useful. Typically, most seed cover technologies are useful for the establishment of warm-season grasses from seed, especially for reducing erosion during establishment.

Table 1. Turfgrass coverage for various seeding blankets after planting zoysiagrass (20).

Blanket	Cover Type	Coverage 5 weeks after planting
		%
Curlex	Permanent	40.0 ab
Deluxe 0.5 oz	Temporary	50.0 a
Futerra	Permanent	41.7 a
Futerra F4 Netless	Permanent	41.7 a
Jute	Permanent	46.7 a
Poly Jute	Permanent	33.3 ab
Polyethylene	Temporary	46.7 a
Straw	Permanent	18.3 b
Straw blanket	Permanent	31.7 ab
Thermal blanket 3.0 oz	Temporary	48.3 a
Uncovered control		41.7 a

Post-Seeding Weed Control

Effective weed control is critical when seeding zoysiagrass in nonfumigated soil because of its slow germination and growth rate and because its optimum seeding period coincides with the germination of summer annual grassy weeds. Zoysiagrass establishment by seed can be significantly reduced if perennial weeds are not completely controlled before renovation and summer annual weeds are not controlled after seeding (21). Though weed species and pressure vary among sites, weeds that commonly reduce zoysiagrass establishment include cool-season grasses, such as perennial ryegrass and annual bluegrass, and warm-season grasses, such as bermudagrass (*Cynodon* spp.), crabgrass (*Digitaria* spp.) and goosegrass (*Eleusine indica*).

Many herbicides are labeled for weed control in established zoysiagrass, but as of 2008, only Quicksilver (carfentrazone) and Drive (quinclorac) are labeled for use on zoysiagrass seedlings. Researchers have realized the need for more studies evaluating the safety of herbicides on zoysiagrass seedlings, and papers have recently been published on this topic. Herbicide applications are based on the date emergence occurs. Researchers working with weed control in seedling zoysiagrass have defined emergence as a uniform stand of one-leaf seedlings about 0.5 inch tall (17,21), which typically occurs 19 to 21 days after seeding but can occur later if seeded when soil and air temperatures are still cool (17,21) or soil moisture is limiting. Seedlings shortly after germination but prior to emergence are pictured (Fig. 4) as well as two- and three-leaf seedlings a week or so after emergence (Fig. 5). Table 2 summarizes the results of research evaluating the safety of herbicide applications timed according to zoysiagrass seedling emergence on either Korean common or Zenith. There are reports of differences in herbicide tolerance among vegetatively established cultivars (10), but it is not known whether seeded cultivars like Compadre tolerate herbicides differently than Zenith and Korean common.

Quicksilver, MSMA, Ronstar (oxadiazon), Barricade (pronamide), Drive, Tupersan (siduron) and Monument (trifloxysulfuron) are among the herbicides that are safest to use on zoysiagrass seedlings.

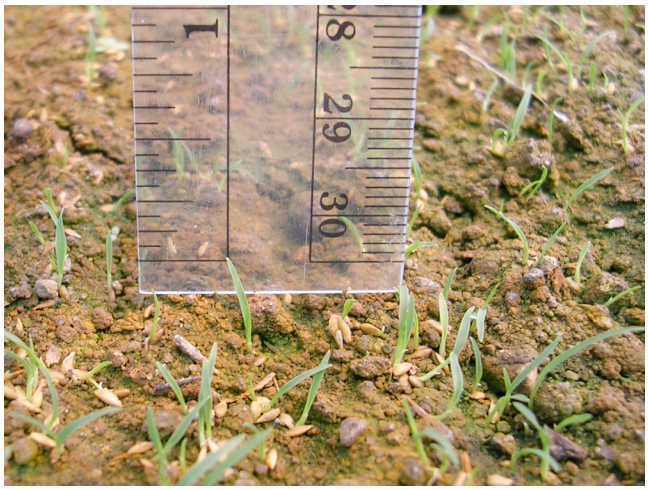

Fig. 4. 'Zenith' zoysiagrass seedlings 14 days after seeding. Most seeds have germinated, but this stand is not quite mature enough to consider emergence (a uniform stand of one-leaf seedlings about 0.5 inch tall). If emergence is judged too soon, herbicide injury will be more severe. Scale is with inches on the left.

Fig. 5. Seedlings have developed past emergence. These plants are predominantly two- or three-leaf seedlings

Tupersan is safe to use on Zenith and Korean common zoysiagrass seedlings for preemergence control of annual grassy weeds and should be applied at the time of seeding (3,11,17,23). After zoysiagrass has germinated, Ronstar is also useful for preemergence weed control and can be applied one week after Zenith zoysiagrass seedling emergence (WAE) (21), which is at least 26 days later than it is safe to apply Tupersan.

Drive and MSMA are safe to use for postemergence control of annual grassy weeds on Zenith zoysiagrass seedlings as early as seedling emergence (3,17,21,25,26). More phytotoxicity can be expected with MSMA than Drive, but effects are short-lived and herbicide damage from early applications can be justified by decreased weed competition (Figs. 6 and 7). Drive and Quicksilver offer selective postemergence control of broadleaf weeds. Drive can be applied at emergence or later, whereas Quicksilver can be applied 1 WAE or later to Zenith zoysiagrass seedlings (25).

Kerb (pronamide) provides selective postemergence control of annual bluegrass and perennial ryegrass without causing damage or growth reduction to Zenith zoysiagrass seedlings (21). This product is registered as a restricted-use pesticide, which could

Fig. 6. Damage to 'Zenith' zoysiagrass seedlings caused by one application of Drive 75 DF (quinclorac) at two weeks after emergence. Picture was taken 10 days after herbicide application.

Fig. 7. Damage to 'Zenith' zoysiagrass seedlings caused by one application of Trimec Classic (2,4-D + dicamba + mecoprop) + MSMA at two weeks after emergence. Picture was taken 10 days after herbicide application.

Table 2. Herbicide safety margins when applied at various timings for use on zoysiagrass seedlings and the target weeds controlled. Listed in approximate order of least phytotoxic to most phytotoxic on zoysiagrass seedlings. Table modified from Patton et al. (19).

Herbicide(s)	Product rate (oz/A)	Rate (lb a.i./acre)	Target weeds controlled preemergently or postemergently	Pre or Post[t]	Margin of safety (delay before or after emergence[u])	Susceptibility to herbicide injury[v]
Tupersan 50 WP (siduron)	192 (12 lb/A)	6.0	Crabgrass, goosegrass, annual bluegrass	Pre	Apply any time before or after seeding (3,11,17,23).	○
Drive 75 DF (quinclorac)	16 (1 lb/A)	0.75	Crabgrass, clover, other broadleaves	Post	Little to no phytotoxicity. Apply any time before or after seeding (3,17,25,26). The Drive XLR8 formulation is reported to have similar safety.	○
Kerb 50 WP (pronamide)	32 (2 lb/A)	1.0	Crabgrass, goosegrass, annual bluegrass, perennial ryegrass	Pre + Post	No phytotoxicity. Apply any time after emergence (21).	○
MSMA	40	2.06	Crabgrass, goosegrass, dallisgrass	Post	Apply any time after emergence; there will be some phytotoxicity (21).	⊙
Monument 75WG (trifloxysulfuron)	0.56	0.026	Annual bluegrass, perennial ryegrass, nutsedge	Post	Phytotoxicity mild[x]. Safe[y] to apply 1 WAE[z] or later (25).	⊙
Quicksilver[w] (carfentrazone)	2.1	0.031	Clover, spurge, other broadleaves	Post	Phytotoxicity mild. Safe to apply 1 WAE or later (25). Label states "delayed until at least 14 days after emergence to avoid extended discoloration."	⊙
Ronstar 50 WSP (oxadiazon)	96 (6 lb/A)	3.0	Crabgrass, goosegrass, annual bluegrass	Pre	Phytotoxicity mild. Safe to apply 1 WAE or later (3,21). Although not tested, Ronstar G is usually safer in seedling turf.	⊙
Monument 75WG + Quicksilver	0.56 + 2.1	0.026 + 0.031	Annual bluegrass, perennial ryegrass, nutsedge, clover, spurge, other broadleaves	Post	Phytotoxicity mild. Safe to apply 1 WAE or later (25).	⊙
Drive + Quicksilver	16 + 2.1	0.75 + 0.031	Clover, spurge, other broadleaves	Post	Phytotoxicity mild. Safe to apply 1 WAE or later (25).	⊙
Turflon Ester (triclopyr)	16	0.5	Clover, spurge, other broadleaves; bermudagrass suppression	Post	Phytotoxicity mild. Safe to apply 2 WAE or later (16).	⊙
Lontrel (clopyralid) + MSMA	16 + 40	0.80 + 2.0	Crabgrass, goosegrass, dallisgrass, clover, spurge, other broadleaves	Post	Phytotoxicity mild. Safe to apply 2 WAE or later (26).	⊙
Drive + MSMA	16 + 40	0.375 + 2.0	Crabgrass, goosegrass, dallisgrass, clover, spurge, other broadleaves	Post	Phytotoxicity mild. Safe to apply 2 WAE or later (26).	⊙
Trimec Classic (2,4-D + dicamba + mecoprop) + MSMA	56 + 40	0.844 + 0.09 + 0.22 + 2.0	Crabgrass, goosegrass, dallisgrass, clover, spurge, other broadleaves	Post	Phytotoxicity mild. Safe to apply 2 WAE or later (23,26).	⊙
Monument 75WG + MSMA	0.56 + 40	0.026 +2.0	Annual bluegrass, perennial ryegrass, nutsedge, crabgrass, goosegrass, dallisgrass	Post	Phytotoxicity mild. Safe to apply 2 WAE or later (26).	⊙

Table 2. Herbicide safety margins when applied at various timings for use on zoysiagrass seedlings and the target weeds controlled. Listed in approximate order of least phytotoxic to most phytotoxic on zoysiagrass seedlings. Table modified from Patton et al. (19) (cont.)

Herbicide(s)	Product rate (oz/A)	Rate (lb a.i./acre)	Target weeds controlled preemergently or postemergently	Pre or Post[t]	Margin of safety (delay before or after emergence[u])	Susceptibility to herbicide injury[v]
Fusilade (fluazifop) + Turflon Ester	6 + 16	0.09 + 0.5	Clover, spurge, other broadleaves; crabgrass and goosegrass; bermudagrass suppression	Post	Phytotoxicity mild. Safe to apply 2 WAE or later (16).	⊙
Acclaim Extra (fenoxaprop) + Turflon Ester	28 + 16	0.12 + 0.5	Clover, spurge, other broadleaves; crabgrass; bermudagrass suppression	Post	Phytotoxicity mild. Safe to apply 2 WAE or later (16). More phytotoxicity than Fusilade + Turflon.	⊙
Dimension 1EC (dithiopyr)	64	0.50	Crabgrass, goosegrass, annual bluegrass	Pre + Post	Safe to apply 2 WAE or later (17,22).	⊙
Dimension 1EC + MSMA	64 + 40	0.5 + 2.06	Crabgrass, goosegrass, dallisgrass, annual bluegrass	Pre + Post	Safe to apply 2 WAE or later (22). No herbicide injury visible two weeks after application.	⊙
Confront (clopyralid + triclopyr) + MSMA	16 + 40	0.093 + 0.278 + 2.0	Crabgrass, goosegrass, dallisgrass, clover, spurge, other broadleaves	Post	Phytotoxicity medium. Safe to apply 2 WAE or later (26).	⊙
Revolver (foramsulfuron) + MSMA	17.4 + 40	0.026 + 2.0	Annual bluegrass, perennial ryegrass, crabgrass, goosegrass, dallisgrass	Post	Phytotoxicity medium. Safe to apply 2 WAE or later (26).	⊙
Katana (flazasulfuron) + MSMA	3.0 + 40	0.019 + 2.0	Perennial ryegrass, broadleaf weeds, sedges, crabgrass, goosegrass, dallisgrass	Post	Phytotoxicity medium. Safe to apply 2 WAE or later (26).	⊙
Revolver	17.4	0.027	Annual bluegrass, perennial ryegrass, dallisgrass	Post	Phytotoxicity medium. Apply 3 WAE or later (21).	⊙
Fusilade	4	0.062	Crabgrass, goosegrass; bermudagrass suppression	Post	Phytotoxicity medium. Apply 3 WAE or later (16,21).	●
Manor 60DF or Blade 60DF (metsulfuron) + MSMA	0.33 + 40	0.021 + 2.0	Crabgrass, goosegrass, dallisgrass, perennial ryegrass, broadleaves	Post	Severe herbicide injury and reduction in zoysiagrass coverage when applied 2 WAE (26).	●
Acclaim Extra + Confront (clopyralid + triclopyr)	28	0.12 + 0.093 + 0.278	Crabgrass, goosegrass, clover, spurge, other broadleaves;bermudagrass suppression	Post	Severe herbicide injury and reduction in zoysiagrass coverage when applied 2 WAE (26).	●
Acclaim Extra	28	0.122	Crabgrass, goosegrass; bermudagrass suppression	Post	Severe phytotoxity and reduction in zoysiagrass coverage (16,21).	●

[t]Herbicides controlled target weeds preemergently (Pre) or postemergently (Post) or both (Pre + Post).

[u]Emergence is defined as a uniform stand of one-leaf seedlings about 0.5 inch tall.

[v]Susceptibility to herbicide injury. Herbicides causing little to no phytotoxicity were classified as safe (○), herbicides causing acceptable phytotoxicity were classified as mild (⊙), those causing phytotoxicity below acceptable limits without killing zoysiagrass seedlings were classified as medium (⊙), and those killing zoysiagrass seedlings were classified as severe (●).

[w]Labeled for use on zoysiagrass seedlings.

[x]Herbicides causing acceptable phytotoxicity were classified as mild, those causing phytotoxicity below acceptable limits without killing zoysiagrass seedlings were classified as medium, and those killing zoysiagrass seedlings were classified as severe.

[y]Herbicides were deemed to be safe when an application did not cause any reduction in seedling coverage.

[z]Weeks after zoysiagrass seedling emergence.

preclude its use on some golf courses. Monument also controls annual bluegrass and perennial ryegrass but is not safe until 1 WAE or later and causes mild phytotoxicity to Zenith zoysiagrass seedlings (25,26).

Herbicides such as Manor or Blade (metsulfuron) and Acclaim Extra (fenoxaprop) cause significant reduction in Zenith zoysiagrass coverage when applied to seedlings and should not be used during establishment (Figs. 8 and 9) (21,26). Other herbicides such as Fusilade (fluazifop) and foramsulfuron can damage Zenith zoysiagrass seedlings (21,26) and, thus, should be used on seedlings only when absolutely necessary and no other weed control options are available (Fig. 10).

Fig. 8. Damage to 'Zenith' zoysiagrass seedlings caused by applications of Acclaim Extra (fenoxaprop) zero and seven days after emergence.

Fig. 9. Damage to 'Zenith' zoysiagrass seedlings caused by one application of Acclaim Extra (fenoxaprop) + Confront (clopyralid + triclopyr) at two weeks after emergence. Picture was taken 10 days after herbicide application.

Fig. 10. Damage to 'Zenith' zoysiagrass seedlings caused by one application of Revolver (foramsulfuron) + MSMA at two weeks after emergence. Picture was taken 10 days after herbicide application.

Recent work has demonstrated that tank-mixing Turflon Ester (triclopyr) with Fusilade or Acclaim can help reduce injury to zoysiagrass (12). A trial was initiated in Arkansas to test whether this would apply to seedlings as well as to established turf. Injury caused by Acclaim Extra alone or Fusilade alone was decreased with the addition of Turflon Ester (16). Zoysiagrass coverage 6 WAE was lowest for Acclaim Extra alone or Fusilade alone, while coverage was greatest for Turflon Ester, Acclaim Extra + Turflon Ester and Fusilade + Turflon Ester. Single or sequential applications of Acclaim Extra or Fusilade tank-mixed with Turflon Ester will reduce zoysiagrass injury, decrease weed coverage and allow for improved zoysiagrass establishment, compared to applications of Acclaim Extra alone or Fusilade alone. Fusilade + Turflon Ester is recommended to remove bermudagrass from zoysiagrass.

Some damage or phytotoxicity may result from herbicides applied shortly after emergence of zoysiagrass. However, under heavy weed pressure, the risk of herbicide damage from early applications may be justified by decreased weed competition eventually allowing increased zoysiagrass coverage.

Post-Seeding Fertilization

Nitrogen (N) fertilization is often increased to quicken establishment. However, research on establishing seeded zoysiagrass found that increasing

monthly nitrogen fertilization from 1.0 to 2.0 lb/1,000 ft^2 does not improve establishment (17). This is similar to work with Meyer in which increasing the annual nitrogen from 1.0 to 4.0 lb/1,000 ft^2 did not hasten establishment from plugs in the initial year (6). Although some nitrogen should be applied during seeded zoysiagrass establishment, applications should be kept to a minimum and not exceed 1.0 lb/1,000 ft^2/month (17). In Arkansas zoysiagrass should receive 1.5 to 3.0 lb/1,000 ft^2/year when used on golf course tees, 1.0 to 2.5 lb/1,000 ft^2/year when used in golf course fairways and about 1.0 lb/1,000 ft^2/year when used on golf course roughs after the initial year of establishment.

Post-Seeding Traffic

Golf cart use allows golfers to enjoy the game and help increase golf course revenue, but carts cause turf wear and soil compaction. Turfgrass seedlings, including zoysiagrass, are adversely affected by soil compaction and wear (34). Traffic on zoysiagrass after seeding reduces zoysiagrass emergence and coverage by more than 50 percent (34). Therefore, limiting or diverting cart and equipment traffic after seeding is strongly advised. When fully established, Zenith zoysiagrass has similar wear tolerance to other zoysiagrass cultivars (29).

Shade

Zoysiagrass is considered to have good shade tolerance compared to other warm-season grasses. The shade tolerance of Zenith zoysiagrass is less than other zoysiagrass cultivars (29). Only recently have the effects of shade on seedling emergence and growth in the field been evaluated. When testing three levels of shade, it was found that zoysiagrass seedling emergence and growth decreased as shade levels increased (35). Specifically, germination and growth were significantly reduced when subjected to 60 percent of normal solar irradiance. This was due, in part, to the reduced soil temperatures in shaded plots and, to a greater extent, because lower surface irradiance inhibits seed germination and seedling growth (35). Therefore, trees should be removed or heavily pruned prior to establishment in areas that are shaded.

Winter Hardiness

Seeded zoysiagrass survives winters in the transition zone with little damage (14). Research in Indiana has also found that seeded zoysiagrass cultivars have excellent freeze tolerance (15). Winter survival of seeded zoysiagrass does not appear to be influenced by seeding date, seeding rate or nitrogen fertility (17).

Costs

As mentioned previously, practices such as strip-sodding and sprigging can be used instead of solid-sodding to reduce establishment costs, but these techniques may require two or more years before zoysiagrass is established. Additionally, zoysiagrass can be established by seed more rapidly and at a lower cost than strip-sodding or sprigging (Table 3). Seed typically costs about $20/lb of PLS. If seeded at a rate of 1.0 lb PLS per 1,000 ft^2, then seed costs per acre are about $900. The cost of seed drops to about $120/acre if zoysiagrass is strip-seeded.

Table 3. Summary of establishment methods and costs for zoysiagrass.

	Establishment Method			
	Sprigging	Strip-sodding	Solid-sodding	Seeding[y]
Establishment cost/acre[z]	$3,000	$5,000	$14,500	$900
Time until 90% coverage	2-3 years	2-3 years	0 day	1 year

[y]Seeding into fallow ground or after a broadcast application of glyphosate.
[z]Cost variable by cultivar. Cultivars used for price estimates in this table are Meyer zoysiagrass (vegetative) and Zenith zoysiagrass (seeded). Labor is not included in establishment cost for seeded varieties. Herbicide costs are not factored into the establishment costs because of the variability between sites and methods. Seeding costs are based on 1.0 lb pure live seed per 1,000 ft^2 at a cost of $20.65/pound of PLS.

Herbicide costs during establishment vary based upon weed pressure, site preparation and seeding technique. A typical herbicide program during establishment might include an application of Roundup prior to seeding, Tupersan immediately after seeding, Drive or MSMA as needed to control summer annual grassy weeds, Quicksilver to control summer annual and perennial broadleaves and Kerb to selectively control perennial grassy weeds, with an estimated cost ranging from $150 to $450/acre. The estimated establishment costs are as follows if herbicide costs

are added to seed costs. Estimated establishment costs excluding labor are about $1,200/acre, including four herbicide applications when seeding into a tilled seedbed.

Summary

The high costs of vegetative establishment have prevented many golf course superintendents from establishing zoysiagrass in spite of reduced long-term maintenance inputs and costs. Seeded zoysiagrass cultivars afford all of the benefits of vegetative cultivars. This publication summarizes research that demonstrates how seeded zoysiagrass can be established successfully. Establishing seeded zoysiagrass will reduce irrigation, pesticide and fertilizer inputs and costs when compared to inputs needed to maintain a cool-season sward. Compared to a bermudagrass turf, zoysiagrass will produce a more playable surface year-round with better winter color and less fertilization and less mowing. Zoysiagrass use can result in Arkansas golf courses that are more environmentally friendly and sustainable, and seeded zoysiagrass makes this goal more attainable.

Summary of Procedures for Establishing Seeded Zoysiagrass

- Apply Roundup to designated areas as needed to control existing perennial weeds.
- Lightly till area and correct any drainage problems.
- Seed 1.0 to 2.0 lb PLS per 1,000 ft^2 of zoysiagrass when soil temperatures reach 68° F (late May).
- Correct nutrient deficiencies and soil pH as indicated by a soil test.
- Apply Tupersan immediately after seeding if high annual weed pressure is anticipated.
- Cover with a temporary germination blanket for 14 days after seeding if budget allows. Alternatively, permanent blankets could be used in sloped areas or level areas if budget allows.
- Maintain a moist seedbed with light, frequent irrigation until plants mature to a point where frequency can be reduced and amount increased.
- Apply herbicides for weed control as soon as possible depending upon safety of individual herbicide, weed species and weed pressure (multiple herbicide applications are usually necessary).
- Begin mowing at 0.5 to 0.75 inch as needed.
- Apply 1.0 lb N per 1,000 ft^2 in June, July and August the initial year.
- Expect 90 percent zoysiagrass coverage in 75 or more days, assuming adequate soil temperatures and moisture. Estimated establishment costs excluding labor are $1,200/acre including four herbicide applications.

Additional Information

Additional publications available at http://www.uaex.edu/.

Additional information about turfgrass management available at http://turf.uark.edu/.

Literature Cited

1. Beard, J. B. 1973. T*urfgrass Science and Culture*. Prentice Hall Inc., Englewood Cliffs, NJ.
2. Boyd, J. 2000. Kill off bermudagrass with one less spraying. *Golf Course Mgmt.* 68(5):68-71.
3. Choi, J. S., and B. J. Johnson. 1995. Influence of pre- and post emergence herbicides on zoysia seedling development. Page 148 in: Annual Meetings Abstracts. ASA, CSSA, and SSSA, Madison, WI.
4. Dozier, M. J. 1986. Effects of various covers on seed germination of zoysiagrass. M.S. Thesis, Southern Illinois Univ., Carbondale, IL.
5. Forbes, I., and M. H. Ferguson. 1948. Effect of strain differences, seed treatment and planting depth on seed germination of *Zoysia* spp. *J. Amer. Soc. Agron*. 40:725-732.
6. Fry, J. D., and P. H. Dernoeden. 1987. Growth of zoysiagrass from vegetative plugs in response to fertilizers. *J. Amer. Soc. Hort. Sci.* 112:285-289.
7. Hanson, A. A. 1966. Meyer zoysia. *Crop Sci*. 6:99.
8. Johnson, C. M., and W. R. Thompson. 1961. Fall and winter seeding of lawns. *Mississippi Farm Res*. 24:4.

9. Johnson, B. J. 1988. Glyphosate and SC-0224 for bermudagrass (Cynodon) cultivar control. *Weed Tech.* 2:20-23.

10. Johnson, B. J., and R. N. Carrow. 1999. Tolerance of zoysiagrass (*Zoysia* spp.) cultivars to preemergence herbicides. *Weed Technol*. 13:706-712.

11. Maki, Y., Y. Bizen and S. Takahashi. 1989. Effect of soil treatment with fungicide and growth promoters on the rate of seedling establishment of Japanese lawn grass *(Zoysia japonica* Steud.). *Int. Turfgrass Soc. Res. J*. 6:269-271.

12. McElroy, J. S., and G. K. Breeden. 2006. Triclopyr safens the use of fluazifop and fenoxaprop on zoysiagrass while maintaining bermudagrass suppression. Online. *Applied Turfgrass Sci.* doi:10.1094/ATS-2006-0502-01-RS.

13. Morris, K. N. 1996. National turfgrass evaluation program. 1991 National zoysiagrass test. NTEP No. 96-15. USDA, Beltsville, MD.

14. Morris, K. N. 2001. National turfgrass evaluation program. 1996 National zoysiagrass test. NTEP No. 01-15. USDA, Beltsville, MD.

15. Patton, A. J., and Z. J. Reicher. 2007. Zoysiagrass species and genotypes differ in their winter injury and freeze tolerance. *Crop Sci.* 47: 1619-1627.

16. Patton, A., and J. Trappe. 2009. Weed control during zoysiagrass establishment from seed. *Arkansas Turfgrass Report 2008*, Ark. Ag. Exp. Stn. Res. Ser. 568:82-85.

17. Patton, A. J., G. A. Hardebeck, D. W. Williams and Z. J. Reicher. 2004. Establishment of bermudagrass and zoysiagrass by seed. *Crop Sci.* 44:2160-2167.

18. Patton, A., D. Karcher, M. Richardson, J. McCalla and J. Landreth. 2008. 2002 NTEP zoysiagrass trial – summary. *Arkansas Turfgrass Report 2007*, Ark. Ag. Exp. Stn. Res. Ser. 557:47-51.

19. Patton, A. J., Z. J. Reicher, A. J. Zuk, J. D. Fry, M. D. Richardson and D. W. Williams. 2006. A guide to establishing seeded zoysiagrass in the transition zone. Online. *Applied Turfgrass Science* doi:10.1094/ATS-2006-1004-01-MG.

20. Patton, A., J. Trappe and M. Richardson. 2009. Seed covers and germination blankets influence seeded warm-season grass establishment – Year 2. *Arkansas Turfgrass Report 2008*, Ark. Ag. Exp. Stn. Res. Ser. 568:69-72.

21. Patton, A. J., D.V. Weisenberger, G. A. Hardebeck and Z. J. Reicher. 2007. Safety of herbicides on 'Zenith' zoysiagrass seedlings. *Weed Tech*. 21:145-150.

22. Patton, A. J., D. W. Williams and Z. J. Reicher. 2004. Renovating golf course fairways with zoysiagrass seed. *HortScienc*e 39:1483-1486.

23. Portz, H. L., J. J. Murray and D. Y. Yeam. 1981. Zoysiagrass (*Zoysia japonica* Steud.) establishment by seed. *Int. Turfgrass Soc. Res. J*. 4:113-122.

24. Portz, H. L., K. L. Diesburg, J. J. Murray and M. J. Dozier. 1993. Early establishment of zoysiagrass with seed under covers. *Int. Turfgrass Soc. Res. J*. 7:870-876.

25. Reicher, Z., and D. Weisenberger. 2005. Tolerance of Zenith zoysiagrass seedlings to quicksilver. Purdue Univ. Online. *Turfgrass Sci. Prog*., 2004 Annu. Rep. 102-104.

26. Richardson, M. D., J. H. McCalla, J. W. Boyd, D. E. Karcher and J. W. Landreth. 2005. Tolerance of zoysiagrass seedlings to postemergence herbicides. *Int. Turfgrass Soc. Res. J.* 10:1240-1244.

27. Samudio, S. H. 1996. Whatever became of the improved seeded zoysia varieties? *Golf Course Manage*. 64:57-60.

28. Teuton, T. C., J. B. Unruh, B. J. Brecke, G. L. Miller and T. C. Mueller. 2005. Hybrid bermudagrass (*Cynodon dactylon* (L.) Pers. × *C. transvaalensis* Burtt-Davy) control with glyphosate and fluazifop. Online. *Applied Turfgrass Sci.* doi:10.1094/ATS-2005-0119-01-RS.

29. Trappe, J., A. Patton, D. Karcher and M. Richardson. 2009. Shade and traffic tolerance of bermudagrass and zoysiagrass. *Arkansas Turfgrass Report 2008*, Ark. Ag. Exp. Stn. Res. Ser. 568:160-164.

30. Unruh, J. B., B. J. Brecke, J. A. Dusky and J. S. Godbehere. 2002. Fumigant alternatives for methyl bromide prior to turfgrass establishment. *Weed Tech.* 16(2):379-387.

31. Yeam, D. Y., J. J. Murray and H. L. Portz. 1981. Physiology of seed germination in zoysiagrass (*Zoysia japonica* Steud.). *Int. Turfgrass Soc. Res. J.* 4:467-476.

32. Yeam, D. Y., J. J. Murray, H. L. Portz and Y. K. Joo. 1985. Optimum seed coat scarification and light treatment for the germination of zoysiagrass (*Zoysia japonica* Steud.) seed. *J. of the Korean Soc. of Hortic. Sci*. 26:179-185.

33. Yu, T. Y., and D. Y. Yeam. 1967. Effects of stratification, coverings of sand and cover of polyethylene film on germination of *Zoysia japonica* seeds. Seoul Nat. Univ. *J. of Agric. and Biology*, series (B) 18:18-25.

34. Zuk, A. J., and J. D. Fry. 2005. Seeded zoysiagrass establishment in a perennial ryegrass sward. *Crop Sci.* 45:1521-1528.

35. Zuk, A. J., D. J. Bremer and J. D. Fry. 2005. Establishment of seeded zoysiagrass in a perennial ryegrass sward: Effects of soil-surface irradiance and temperature. *Int. Turfgrass Soc. Res. J.* 10:302-309.

Printed by University of Arkansas Cooperative Extension Service Printing Services.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director, Cooperative Extension Service, University of Arkansas. The Arkansas Cooperative Extension Service offers its programs to all eligible persons regardless of race, color, national origin, religion, gender, age, disability, marital or veteran status, or any other legally protected status, and is an Affirmative Action/Equal Opportunity Employer.

MP476-PD-5-09N