TURFGRASS TRENDS

BIODIESEL

Biofuels Help Power Kentucky Operation

Superintendent offers a practical guide to converting vegetable oil to biodiesel to use as an alternative fuel

By Christopher S. Gray Sr.

When I started using vegetable oil to make biodiesel three years ago, it was mainly due to my staunch environmental principles that I've applied to my career in golf course management. I feel biofuels are the best option, environmentally, for fueling my diesel equipment. The economics of using vegetable oil to make biodiesel was never my primary motive for developing and implementing my alternative fuel program. But three years later, while experiencing the highest diesel fuel prices on record, these alternative fuels are helping me keep my maintenance budget in line.

Biodiesel is the leading alternative fuel, environmentally speaking. In 2000, biodiesel became the only alternative fuel in the country to have successfully completed the EPA-required Tier I and Tier II health effects under the Clean Air Act. What this means is that biodiesel significantly reduces all regulated emissions while posing no threat to human health. Biodiesel also provides a positive net energy balance. According to the National Biodiesel Board, "for every unit or energy that is required to produce a gallon of biodiesel, 3.24 units of energy are gained."

Biodiesel is a fuel that can be used directly in any diesel engine without physical modifications to the engine. This characteristic alone makes this alternative fuel very attractive. It does, however, require that vegetable oil (new or used) go through a chemical process called transesterfication, where the glycerin is separated from the oil by replacing the glycerol bond with alcohol. When the process is successfully completed, the viscosity of the base vegetable oil has been significantly reduced to the point of being similar to that of petroleum diesel fuel.

Rather than purchase biodiesel from a local supplier, I found it much more cost effective to produce my own in my maintenance facility. After much research and tweaking my recipe, I have become rather efficient at it. It's really a much simpler process that you might expect.

The mixture

My recipe for making biodiesel will produce about 35 gallons to 40 gallons, depending on the quality of the oil used. This recipe will work for both new vegetable oil as well as waste vegetable oil from the clubhouse's deep fryer or other local res-

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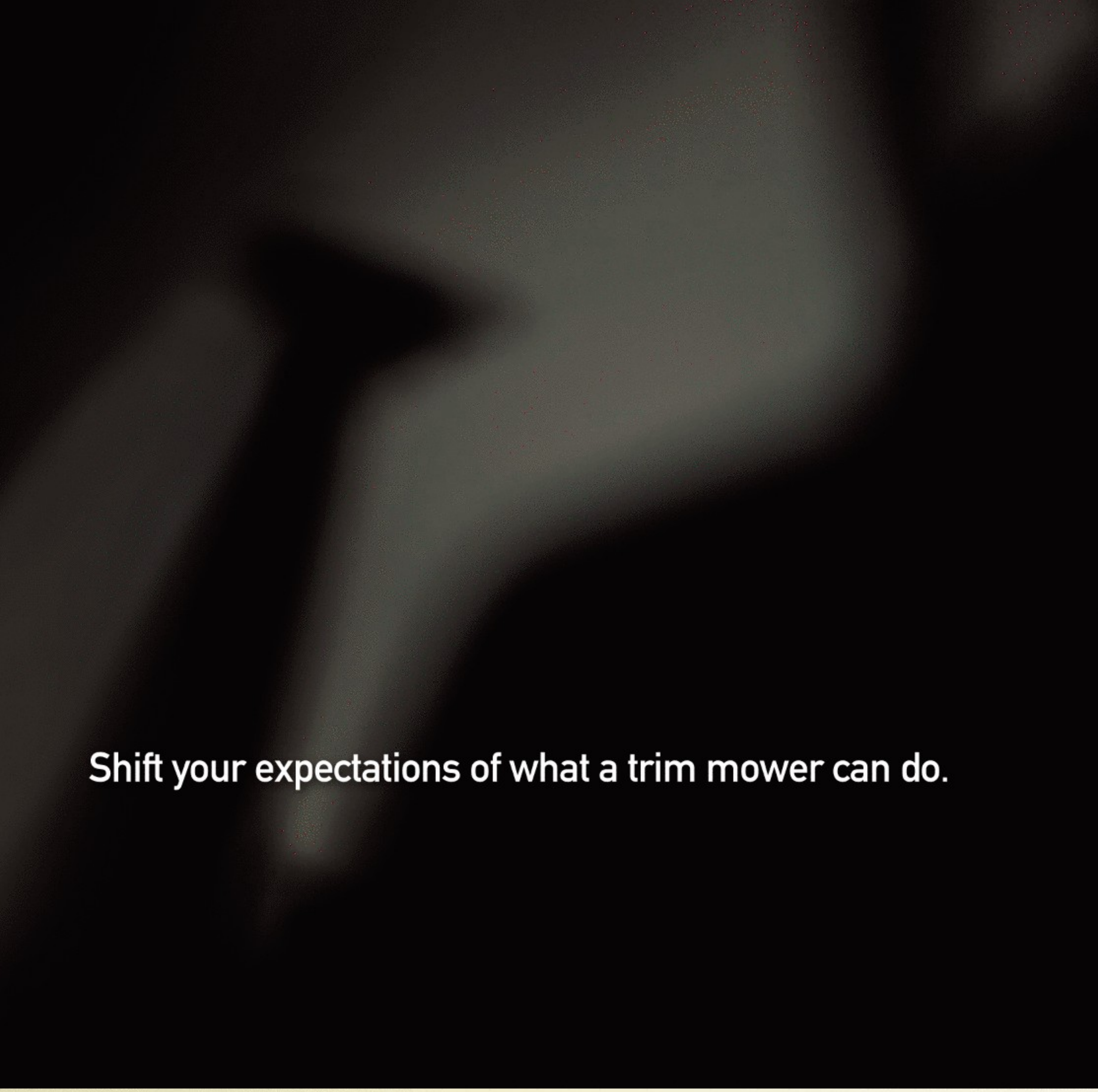

Comparison Chart	7400 TerrainCut	Toro 3500	Jacobsen AR-3
Mowing Width	Width On Demand 68" or 74"	68" or 72"*	72"
Width-of-Cut Adjust From Seat	Yes	No	No
Max Trimming Reach	15"	12" or 14"**	8"- Left side only
Engine Net Horsepower	36† (26.8 kW) @2600 RPM	32 (23.9 kW) @2800 RPM	32.8 (24.5 kW)
Fuel Capacities Gallon (L)	13 (49.2 L)	11 (42 L)	12 (45.4 L)

* 72" CONFIGURATION REQUIRES LIFT ARM CHANGE. **14" TRIMMING REACH ONLY WITH 72" WIDTH OF CUT.
† ENGINE HP IS PROVIDED BY ENGINE MANUFACTURER FOR COMPARISON PURPOSES. ACTUAL OPERATING HP WILL BE LESS.

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taurants. If waste vegetable oil is going to be used, it must be filtered through a 1-micron filter to ensure all the little bits of French fries and such won't clog your injector pump or injectors.

When brewing biodiesel in your maintenance facility, there is one piece of equipment that is absolutely necessary: a processor. Before you start thinking about how much one of these processors will set you back, let me ease your mind and tell you there is a very economical solution: a hot water heater. You will need to add a couple things to the hot water heater to make it into a fully functioning processor, including an additional few holes on the top and a mechanical stirring device. These additions are very simple and inexpensive to implement. I have been using a hot water heater since the beginning, and it has worked perfectly. The size of the hot water heater is the limiting factor on the recipe production of 35 gallons to 40 gallons. The larger the processor you use, the larger the batches of biodiesel you can produce. You can always upgrade after becoming more comfortable with the production process.

Obtain and place 40 gallons of either new or filtered waste vegetable oil in your processor and use the processor to heat the oil to 120 degrees Fahrenheit. Allow proper time for all the oil to reach the correct temperature. By heating the oil, you are reducing the viscosity of the oil to allow for a better chemical reaction to take place.

While you are waiting for the oil to heat, you can start to prepare the methoxide. This is the most dangerous part of the production process. I can not stress enough the need for safety precautions with this step of the recipe. Please wear gloves and a mask when creating the methoxide. Methoxide produces poisonous fumes. Be extremely careful. You will be mixing lye (sodium hydroxide, NaOH) with methanol to create the methoxide necessary for the transesterfication chemical process to occur. Lye can be found and purchased from any hardware store in the drain-cleaning section. Methanol can be obtained through most petroleum distributors in 55-gallon drums. It can also be located at race tracks where it is used as racing fuel.

Find two clean 5-gallon buckets and drill a quarter-inch hole in the center of each lid. Pour 4 gallons of methanol into each bucket, and place the lids on both buckets (Eight total gallons is 20 percent of the total volume of vegetable oil in this particular batch).

The amount of the lye needed for the methoxide mixture will depend on whether you are using new vegetable oil or waste vegetable oil. New vegetable oil is relatively simple to determine: 5 grams of lye for every liter of new vegetable oil. So for a 40-gallon batch, you will need approximately 1.66 pounds of lye. Waste vegetable oil would normally require a titration test to determine the extra amount of lye need beyond that of the base number of 5 grams per liter. I can help out with this. After three years of endless titration tests, I have found that the "average" waste vegetable oil needs an additional 2.5 grams of lye for a successful chemical reaction to occur, or a total of 2.5 pounds of lye for waste vegetable oil for this recipe.

Take the total amount of needed lye and divide it in half and place the two halves in two separate containers. Take the containers of lye over to the two buckets of methanol and prepare to mix them together. This is the point where you need protective gloves and a mask; remember that methoxide not only has poisonous fumes but it is also very flammable. Remove the lid of the first bucket and start stirring the methanol with a clean stick. While the methanol is spinning, add the lye from one of the containers to the first bucket. Continue to stir for about one minute. Place the lid back on the bucket and allow it to stand for several minutes. Remove the lid again on the first bucket and begin stirring again. You will need to continue mixing until the lye is completely dissolved in the methanol; this will take approximately 10 minutes. When finished with the first bucket, you will need to repeat this process for the second bucket.

With two buckets of methoxide ready to go, check on the oil in the processor to ensure that proper temperature of 120 degrees has been reached. It can be a slightly above 120 degrees, but can not be any lower. Wearing your protective gloves and mask, remove the lids from each bucket. Very carefully pour the methoxide into the processor with the vegetable oil.

The mechanical mixing device I mentioned earlier that will need to be added to a hot water heater is ready to be turned on. In a pinch you can use a long, clean stirring stick and mix the contents by hand. Physically mixing the methoxide and the vegetable oil will cause the chemical reaction of transesterfication to occur. There is a specific procedure to the mixing process to ensure success. First, mix the oil and methoxide for five minutes. You will then wait exactly 10 minutes with no mixing. This process of mixing for five minutes and waiting for 10 minutes will need to be repeated four times for a total of one hour of mixing/waiting. After the mixing process has been completed, turn off the processor and let the contents cool.

PHOTO 1

Marvel Golf Club Superintendent and General Manager Christopher S. Gray Sr. says making your own biodiesel likely will void your warranty, so experimentation should be conducted on older equipment.

Refining time

Let the mixture sit for at least eight hours. During this time, the biodiesel and glycerin will completely separate from one another. The biodiesel will rise to the top of the processor, while the glycerin will fall to the bottom. Once the eight hours is over, you will need to remove the glycerin from the processor. Again, a hot water heater already has a drain spout that makes this step very easy. The glycerin you remove can be used as a degreaser or used to make soap, or simply discarded. All that should be left in the processor at this point is unwashed biodiesel.

The biodiesel needs to be thoroughly washed to remove any residue from the chemical process. There are two different methods of washing the biodiesel that should be used for a complete washing. The first method is misting. Turn on the mechanical mixing device of the processor to get the biodiesel turning and then, using a light mist applicator tip, add 15 gallons of water. When all 15 gallons have been applied, turn off the processor and allow it to sit for 10 minutes and then drain off the water with the drain valve. After draining, turn on the mixing device again and use a more aggressive mist to add an additional 15 gallons of water. Turn off the processor and allow the biodiesel to sit again for 10 minutes. *Do not* drain the water this time around.

Now it's time to add a "bubbler" to the bottom of the processor to emulsify the biodiesel. The least-expensive, but very effective bubbler to use is a simple fish tank aerator available at any pet store. Turn on the bubbler and start with a very light bubble and watch for emulsion to occur. If there is no emulsion, turn up the bubbler rate. Leave the bubbler in the biodiesel for at least 24 hours.

After 24 hours, turn off and remove the bubbler. Allow the biodiesel to sit for an additional eight hours to make sure the water and biodiesel separates completely. Once separated, you need to drain off the water layer in the processor, which should be very clear in its color. In the event that the water is very cloudy, it would be best to re-wash the biodiesel again.

The washed biodiesel should be the only remains left in the processor. You will need to have several clean 5-gallon buckets on hand to put the washed biodiesel into

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from the processor. Take the open buckets with the washed biodiesel and place them into the sun to allow the excess moisture to evaporate. I would also suggest placing screens on the tops of the buckets to keep out bugs and other debris from contaminating your newly created fuel. The biodiesel will need to sit approximately eight hours to dry, at which point the biodiesel will be relatively clear. You should be able to see the bottom of the bucket. Once dry, pour the biodiesel into fuel container for use in your diesel equipment.

PHOTO 2

Lye and methanol are the ingredients that help allow transesterfication.

Pros and cons

As you see, it's not that complicated to do. I get a lot of calls and e-mails from fellow superintendents and other industry professional asking about the economics of making biodiesel. Here's a quick breakdown of costs, which will vary from region to region, but it will give you an idea on what's really involved with this: A simple hot water heater will cost about \$350, the mechanical mixing device is about \$200 (I have simple design plans available to anyone who wants them), the methanol costs approximately \$3.65 a gallon (available in 55 gallon drum), and lye costs approximately \$3.50 a pound. Obviously there are other costs associated with making biodiesel, such as labor, but these costs are the ones most requested and give you a much clearer picture of the actual expenses of the process.

But there is one crucial caveat to producing your own biodiesel: This will, in fact, void your warranty on any piece of equipment that you use it in regardless of the amount used. Turf equipment manufacturers are not supportive of the idea of using a self-made fuel source.

Several equipment manufacturers only recently began to accept limited use of biodiesel blends in their equipment, and they have severely limited what can be used and not void their warranty. The Toro Co. recently clarified its position on biofuels saying that while five percentage (B5) blends are preferred, biodiesel concentration up to 20 percent (B20) can *only* be used if the original biodiesel meets national highway standards under ASTM D6751. The biodiesel produced in almost every small operation does not meet this criterion. For this reason, older diesel equipment out of warranty should be implemented for use of either biodiesel or vegetable oil. Any specific questions regarding warranty issues should ultimately be directed at the manufacturer of the equipment you intend to use.

Producing biodiesel has been around for more than 30 years with most of the bugs worked out in the system. I have been producing and using biodiesel in my diesel turf equipment for three years with no problems or disastrous stories of engines locking up. I am an advocate and promote the use of biodiesel to anyone who wants to learn about it. But at the end of the day, whether or not to produce and use biodiesel in your golf operation lies on the shoulders of the person who will be responsible if something goes wrong. Things can, and do, go wrong with any system. But in a time with ever-increasing fuel prices wreaking havoc on our maintenance budgets, it's our responsibility to investigate any and all options available to us.

Christopher S. Gray Sr. is superintendent and general manager of the Marvel Golf Club in Benton, Ky. He can be reached at cgray@marvelgolf.com.

Improved Zoysia Cultivar Could Have Use in Transition Zone

By Jack Fry, Qi Zhang, David Okeyo, Milt Engelke and Dennis Genovesi

The northern border of the turfgrass transition zone in the United States is roughly Interstate 70 from Maryland through eastern Kansas. The southern boundary is roughly the southern borders of North Carolina, Kentucky and Tennessee (Dunn and Diesburg, 2004). Whether or not a particular warm-season turfgrass species or cultivar will perform well in the transition zone is usually determined by its ability to persist through the coldest of winters. Bermudagrass [*Cynodon dactylon* (L.) Pers.], buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] and zoysiagrass (*Zoysia* spp.) are used throughout the transition zone and heralded for their heat and drought tolerance. Buffalograss is the most tolerant to cold among the three species with LT50s (the temperature that is lethal to 50 percent of the population) ranging from -14.0 to -21.7 degrees Celsius (Qian et al., 2001), followed by zoysiagrass (-8.4 to -11.5 C) (Patton and Reicher, 2007), and bermudagrass (-7.0 to -11.0 C) (Anderson et al., 1988, 1993).

Zoysiagrass is native to Asia and the South Pacific, along the eastern Pacific Rim to westward of the Indian Ocean (Engelke and Anderson, 2003). David Fairchild, son of George Fairchild, who was Kansas State University President from 1879 to 1897, introduced *Z. japonica* Steud. as Plant Introduction 9299 into the United States in 1902 (Fairchild, 1938). Among the 11 zoysiagrass species identified, three have been grown as turfgrasses in the United States since the 1930s (Halsey, 1956; Engelke and Anderson, 2003). *Zoysia pacifica* (Goudsw.) M. Hotta & Kuroi produces a very attractive turf with the finest leaf texture, but is only used in areas of Florida and Southern California, as it does not tolerate cold weather.

Grasses in the *Z. matrella* (L.) Merr. group form a thick and tough turf that is wear resis-

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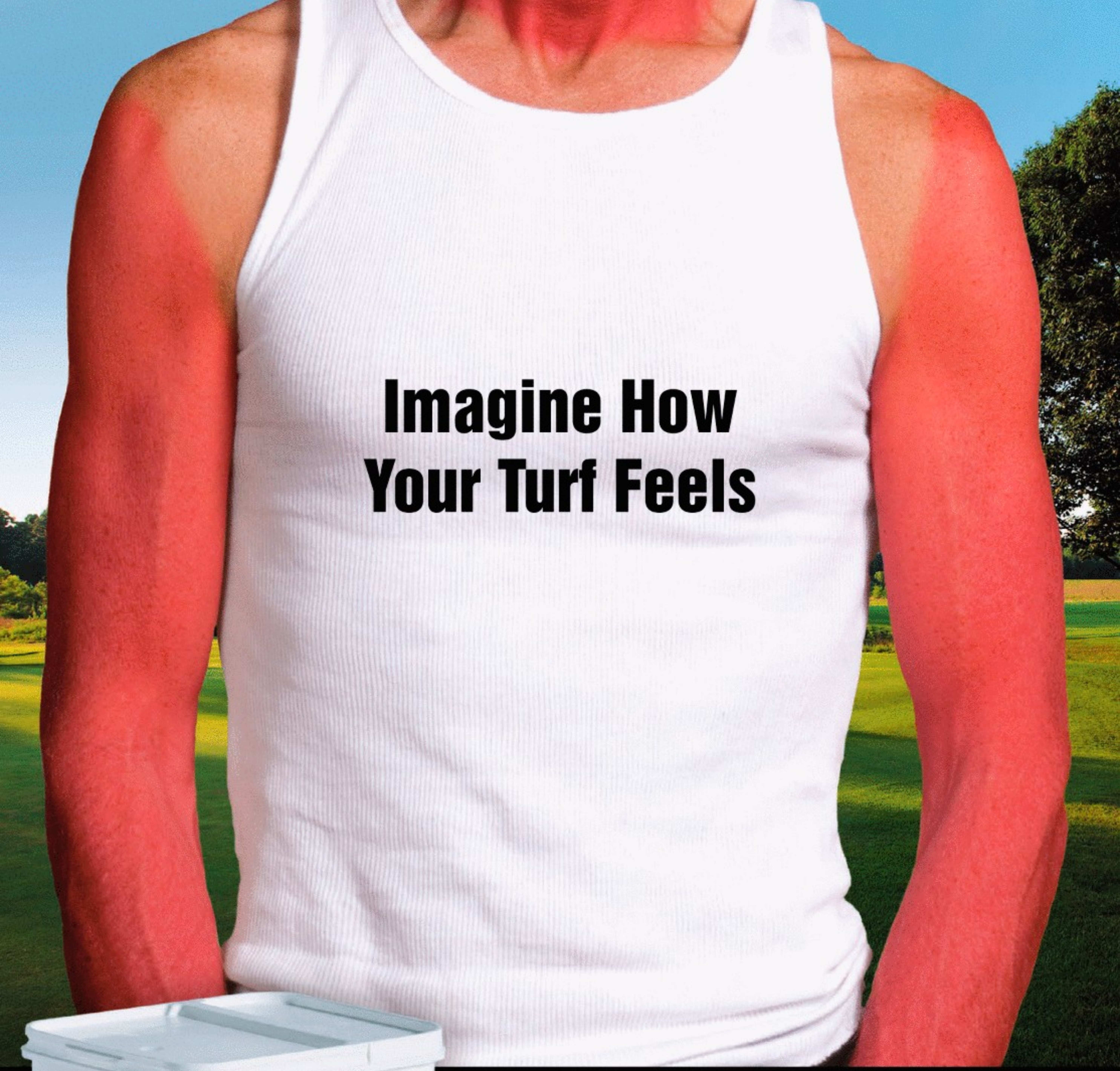
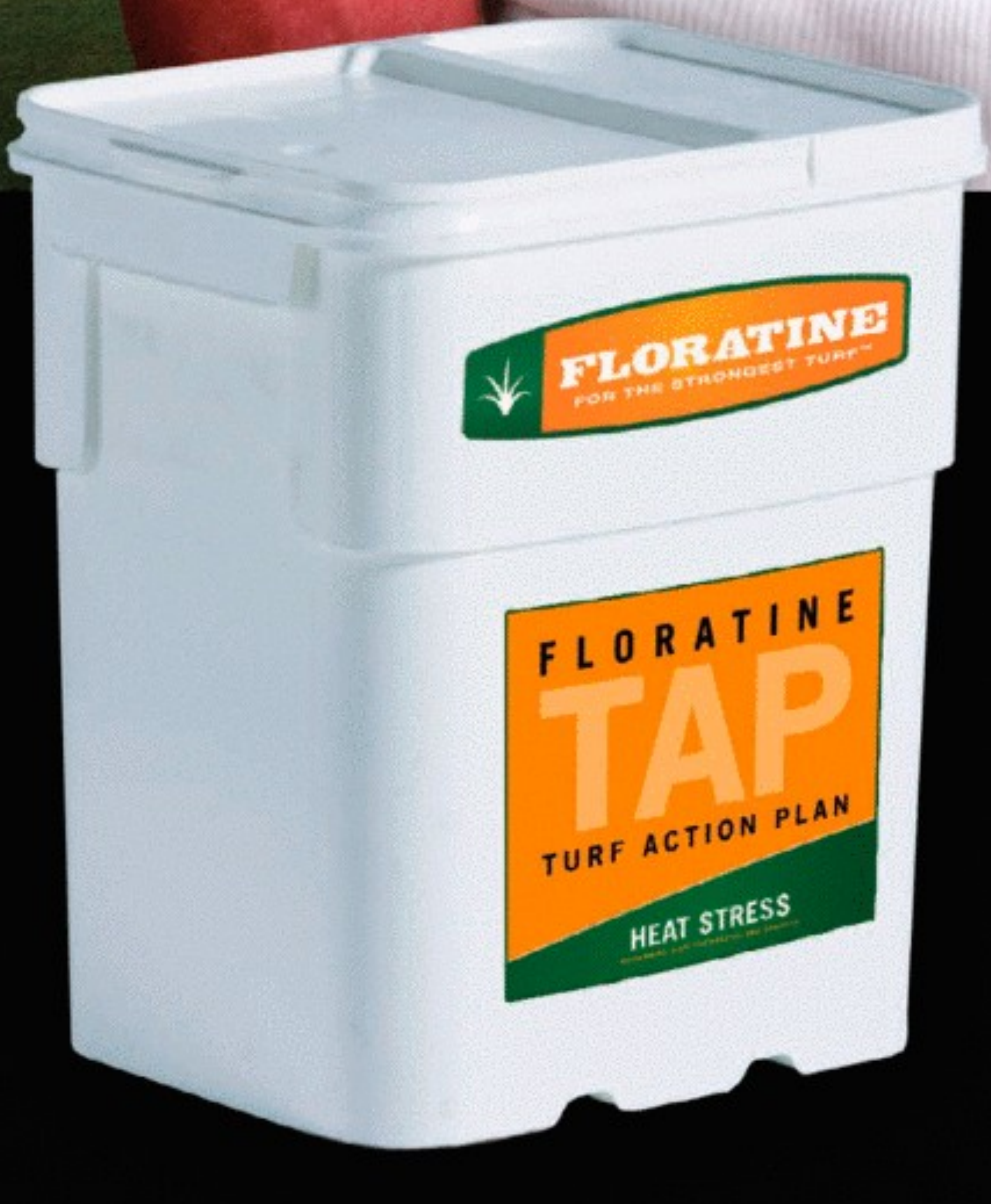
PHOTO 1

Zoysiagrass progeny is developed at Texas A&M University-Dallas and evaluated in the field at Manhattan, Kan.


Imagine How
Your Turf Feels


FLORATINE
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tant but lack sufficient cold hardiness for use in the transition zone. Those grasses found in the Z. *japonica* group have the best cold hardiness among the three turf-type zoysia species, but most have a coarse leaf texture and inferior turf quality (Halsey, 1956).

Meyer zoysiagrass (*Z. japonica*) is named after Frank N. Meyer who collected zoysia seed in Korea in 1905 (Grau and Radko, 1951). Since the release of Meyer in 1952, it has been the principal commercial cultivar used in the transition zone, primarily because of its excellent freezing tolerance. As good as Meyer is, it does have limitations, including a coarse leaf texture when compared to cultivars of *Z. matrella*. It also has slow establishment and recuperative rates (Fry and Dernoeden, 1987), relatively shallow rooting depth and below-average drought avoidance capability (Marcum et al., 1995), and susceptibility to some pests, including the disease large patch (*Rhizoctonia solani* Kühn) (Green et al., 1993).

Researchers at Texas A&M University and the U.S. Department of Agriculture collected *Zoysia* germplasm in Asia in the 1980s, and some of this material ultimately contributed to the development and release of several vegetatively propagated zoysiagrass cultivars including Cavalier (*Z. matrella*) (Engelke et al., 2002a), Crowne (*Z. japonica*) (Engelke et al., 2002b), Diamond (*Z. matrella*) (Engelke et al., 2002c), and Palisades (*Z. japonica*) (Engelke et al., 2002d). All of these varieties exhibited high turf quality scores in evaluations from Southern states, but lacked the freezing tolerance necessary for long-term survival in the transition zone (NTEP, 2002). In a controlled freezing chamber experiment, Belair (*Z. japonica*), Chinese Common (*Z. japonica*), and Meyer exhibited regrowth from rhizomes exposed to -18 C, but no living tissue regrowth was observed with Cavalier, Crowne, Emerald (*Z. japonica* x *Z. pacifica*) or Palisades after exposure to temperatures below -10 C (Dunn et al., 1999). Winter injury field observations taken on 35 zoysiagrass varieties in Indiana have supported this controlled environment research. There, Diamond had the highest winter injury (98 percent to 100 percent tissue death), followed by Palisades (31 percent to 61 percent) and Cavalier (17 percent to 45 percent); whereas, Meyer and Chinese Common had no injury (Patton and Reicher, 2007).

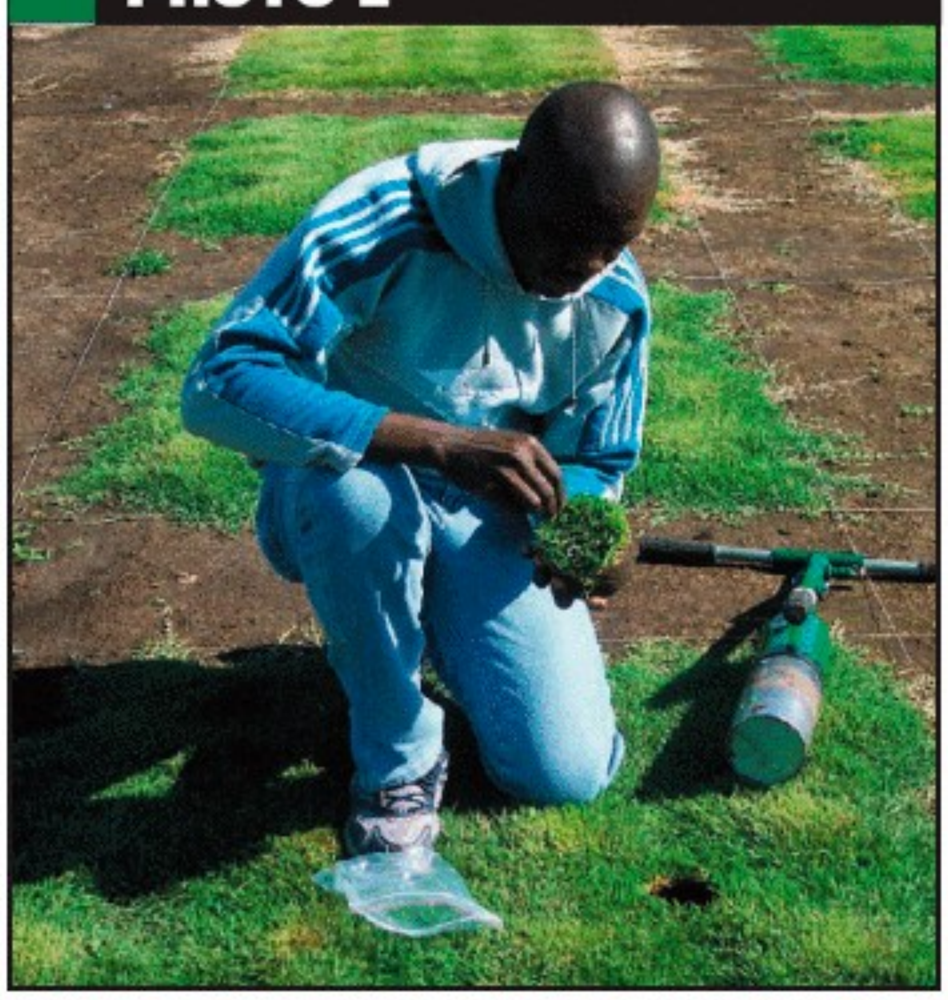
Recently, researchers at Texas A & M crossed some of the aforementioned high-quality cultivars with cold-hardy *Z. japonica* in an effort to produce a cold-hardy cultivar with better quality and, potentially, a faster spread and recovery rate than Meyer. Some of the *Z. japonica* parental lines included in these crosses were Meyer and two selections of Chinese Common that were seeded at Alvamar Country Club in Lawrence, Kan., in the 1950s (referred to as Anderson No. 1 and No. 2 after Mel Anderson, the golf course superintendent who originally seeded these common *Z. japonica* cultivars).

In 2004 and 2005, more than 600 zoysiagrass progeny (offspring), most originating from crosses of a *Z. japonica* with a *Z. matrella*, were transported to Manhattan, Kan., from Texas A&M-Dallas and planted as single 4-inch-diameter plugs on 3-foot centers in a large nursery (Photo 1, p. 58).

From 2004 to 2007, we evaluated the grasses for cold hardiness, rate of spread and leaf texture. In 2006 to 2007, 31 of the top performing progeny were propagated in the greenhouse for more comprehensive evaluation under golf course fairway maintenance conditions.

The first week of June in 2007, these 31 progeny were planted as 3-inch-diameter plugs on 1-foot centers in 5-by-5 foot field plots with

PHOTO 2



Ph.D. student David Okeyo evaluates new zoysiagrass progeny in the field in Manhattan, Kan.