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RESEARCH

Effects of hydraulic fluids on warm-season putting greens

Comparisons of a synthetic hydraulic fluid and hydraulic oils commonly used in the turf industry showed that a spill of the synthetic hydraulic fluid caused less damage than the hydraulic oils on warm-season putting greens.

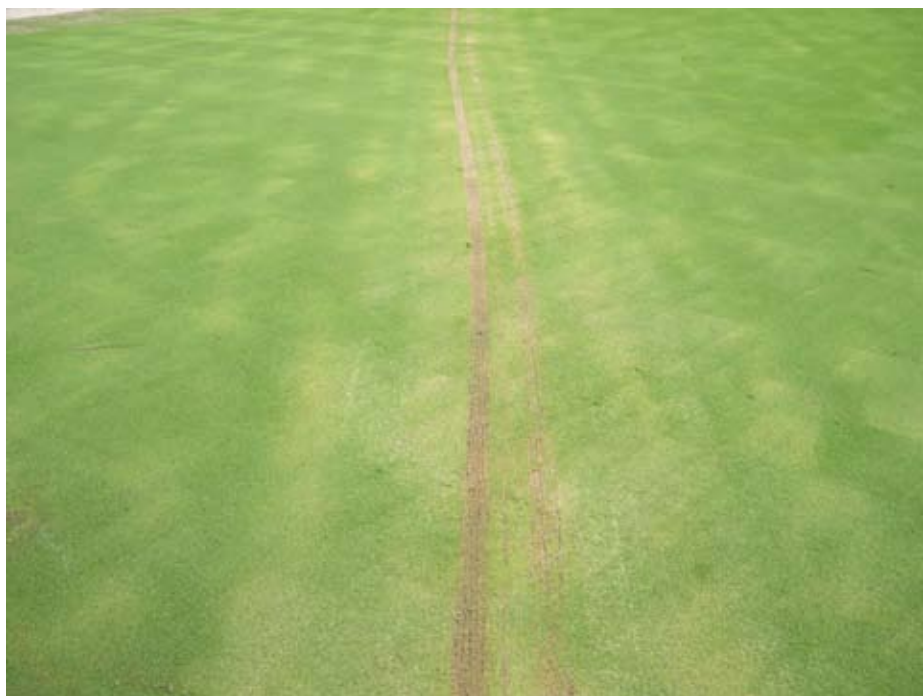
William L. Berndt, Ph.D.

Hydraulic systems are essential for the operation of many different types of golf course equipment, but unfortunately hydraulic oil is sometimes spilled on turf, injuring the turf to some degree, depending on the turf type, the nature of the hydraulic oil, the volume of oil spilled and the temperature of the oil at the time of the spill (Figure 1). The release of hydraulic oil onto a green also pollutes the environment. Thus, the development of alternative hydraulic fluids that are not toxic to turf and that minimize the potential for environmental pollution would be highly desirable.

Research involving a synthetic hydraulic fluid developed specifically for the golf course industry (EnBio TC S) is now being conducted at Edison College in Fort Myers, Fla. The major objective of this research is to determine whether the release of this fluid onto warm-season putting greens injures the turf. Experimental factors include the volume of fluid released onto the turf, the temperature of the fluid at the time of release and the type of turf the fluid is spilled on. Several recent lab and field experiments have compared the effects from spills of the synthetic hydraulic fluid against the effects from spills of industry standards, including petroleum/mineral-based hydraulic oil and biodegradable vegetable/ester-based hydraulic oil.

A container study with TifEagle

A container experiment in June 2005 showed that the synthetic hydraulic fluid caused substantially less turf injury and preserved a greater degree of rooting than either biodegradable vegetable/ester-based hydraulic oil or petroleum/mineral-based hydraulic



Photos courtesy of Noel Chandler

Figure 1. The effect of a hydraulic oil spill on a hybrid bermudagrass putting green in southwest Florida.

oil when spilled onto TifEagle bermudagrass turf (data available from the author).

A field study with TifEagle, Tifdwarf and Sea Isle I

The objective of this study was to determine the relative effect of four different hydraulic fluids spilled onto three different warm-season turfgrass cultivars maintained as putting greens.

Materials and methods

The experimental plots were established in

October 2005 on three warm-season putting greens on the Lee County Campus of Edison College in Fort Myers, Fla. A different cultivar was planted on each green: TifEagle hybrid bermudagrass (*Cynodon dactylon* L. [Pers.] × *C. transvaalensis* Burt Davy), Sea Isle I seashore paspalum (*Paspalum vaginatum* O. Swartz) and Tifdwarf hybrid bermudagrass (*C. dactylon* L. [Pers.] × *C. transvaalensis* Burt Davy).

Greens were constructed in September 2003 according to USGA recommendations. The supporting greens mix was 90:10 sand:

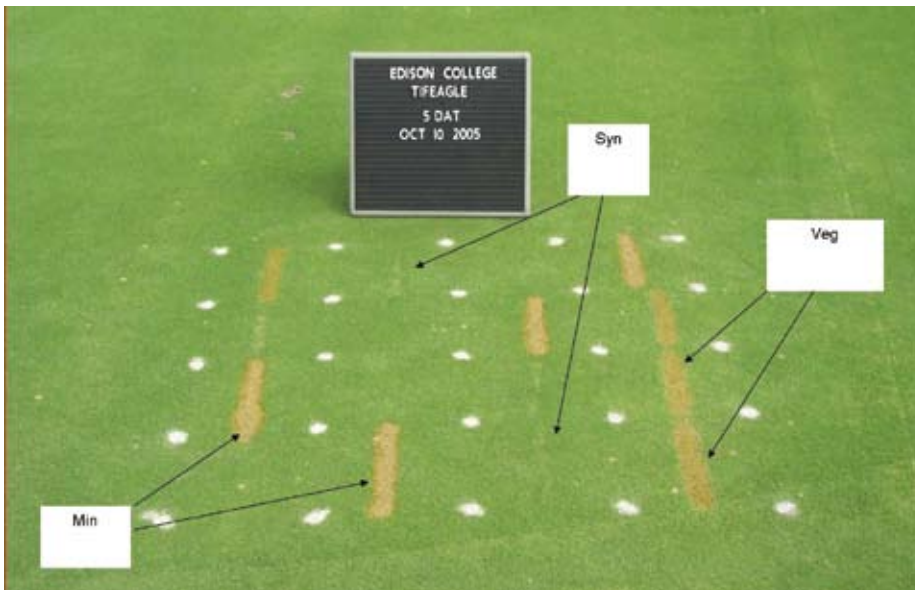


Figure 2. The effect of hydraulic fluids spilled on TifEagle hybrid bermudagrass five days after treatment. Both vegetable/ester-based oil (Veg) and the petroleum/mineral-based oil (Min) readily killed turf. The synthetic hydraulic fluid (Syn) burned the turf slightly. The volume of each spill was 0.67 ounce (20 milliliters).

peat by volume mixed off site. The greens were mowed daily with a triplex greensmower equipped with 11-blade reels and tournament bedknives and bench-set at 0.15 inch (0.38 centimeter). The greens were fertilized using a greens-grade 10-2-20 at a basic rate of 0.5 pound nitrogen/1,000 square feet (2.44 grams/square meter) every two weeks and were irrigated as necessary.

Experimental plot size was 12 inches × 12 inches (30.5 centimeters × 30.5 centimeters). Treatments for this study consisted of a synthetic hydraulic fluid, a biodegradable vegetable/ester-based hydraulic oil, a petroleum/mineral-based hydraulic oil, and water, which served as a control. The experimental design was a randomized complete block with four replications.

Treatments were applied to the turf using a plastic syringe with all fluids at ambient temperature. The volume of each fluid spilled was 20 milliliters (0.67 ounce). Fluids were spilled in straight lines within the confines of each plot through the center of each plot from a height of about 0.5 inch (1.3 centimeters), so as to simulate fluid leaking from a machine in operation. No washing occurred, and no irrigation was applied within eight hours of the application.

Results

Each set of plots was evaluated at five, 15 and 30 days after treatment for burn severity and area of injury (Figure 2, Table 1).

By day 5, observations showed that the turf treated with the vegetable/ester-based oil and the petroleum/mineral-based oil was burned severely. These two hydraulic oils consistently produced larger areas of turf damage with more intense burn for the 20-milliliter (0.67-ounce) spill than did the synthetic hydraulic fluid. This was true for all turf types. By 15 days after treatment, the plots where synthetic hydraulic fluid had been spilled had healed completely. This was also true for all turf types.

Two trends emerged. First, for a given volume of vegetable-based or petroleum-based oil, the size of the damaged area was greater for Tifdwarf than for TifEagle. Similarly, the size of the damaged turf area was larger for TifEagle than for seashore paspalum. Second, the same volume of vegetable-based oil caused much less damage than the petroleum-based oil to seashore paspalum. The synthetic hydraulic fluid caused the least turf

TURF DAMAGE

Cultivar	Synthetic		Vegetable		Mineral	
	Injury [†]	Burn [‡]	Injury [†]	Burn [‡]	Injury [†]	Burn [‡]
5 days after treatment						
Tifdwarf	8.1	2.1	36.1	10.0	41.2	10.0
TifEagle	7.3	1.6	22.5	10.0	29.5	10.0
Sea Isle I	7.3	1.3	11.6	4.0	14.3	10.0
LSD _{P=0.1}	4.7	0.3				
15 days after treatment						
Tifdwarf	0.0	0.0	31.9	10.0	41.2	10.0
TifEagle	0.0	0.0	22.3	10.0	31.8	10.0
Sea Isle I	0.0	0.0	8.5	5.7	18.0	10.0
LSD _{P=0.1}	4.5	0.5				
30 days after treatment						
Tifdwarf	0.0	0.0	29.6	10.0	39.8	10.0
TifEagle	0.0	0.0	22.3	10.0	32.6	10.0
Sea Isle I	0.0	0.0	4.5	4.0	17.5	10.0
LSD _{P=0.1}	4.0	<0.1				

Note. For the control, the injury area was always 0.0 and the burn rating was always 0 = no burn.

[†]Area of turf injured by each spill in square inches.

[‡]Burn rating: 10 = turf death; 0 = no burn.

Table 1. Area of turf injury in square inches and burn ratings from three types of hydraulic fluids spilled on three different warm-season turfgrass cultivars maintained at 0.15 inch. Spill volume was 0.67 ounce per spill. Plot size was 144 square inches. All fluids spilled were at ambient temperature, which was 84.9 F. Spills occurred on Oct. 5, 2005.

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damage for all turf types.

Where the vegetable-based oil was spilled on Tifdwarf, the recovery process seemed to begin by 30 days after the spill, but the effect of petroleum-based oil lingered. For TifEagle, the effect of the vegetable-based oil lingered and the effect of the petroleum-based oil actually increased. For Sea Isle I, the healing process for vegetable-based oil began relatively quickly, but the effect of the petroleum-based hydraulic oil seemed to increase and linger.

This field study showed that the synthetic hydraulic fluid caused substantially less damage to the turf in terms of the area of turf damaged and the associated degree of burn than either the biodegradable vegetable/ester-based hydraulic oil or petroleum/mineral-based hydraulic oil. The petroleum-based hydraulic oil appeared to cause larger areas of turf damage than the vegetable-based hydraulic oil. The Tifdwarf appeared to be affected more than the TifEagle, and the Sea Isle I was affected the least.

This experiment was conducted again beginning in March 2005 with statistically similar results.

Fluid type, fluid volume and fluid temperature

A second experiment was performed to determine the relative effect of the volume and temperature of four different hydraulic fluids spilled onto a warm-season grass putting green.

Materials and methods

The experimental plots were established on the Tifdwarf putting green described above. The turf was maintained as in the previous experiment. Thatch at the time of the study was 1.2 inches (3.1 centimeters) thick, had a bulk density of 0.39 ounce/cubic inch (0.67 gram/cubic centimeter), and a carbon:nitrogen ratio of 14:1.

Treatments were a synthetic hydraulic fluid, a biodegradable vegetable/ester-based hydraulic oil, a petroleum/mineral-based hydraulic oil, and water, which served as a control. These four fluids were heated to 122 F, 140 F, 158 F or 176 F (50 C, 60 C, 70 C or 80 C) and then released onto the surface of the turf at the center point of each plot from a distance of 0.5 inch (1.3 centimeters) at spill volumes of 1, 3 or 5 milliliters. The intent was to simulate a spill of warm

DAMAGED TURF AREA

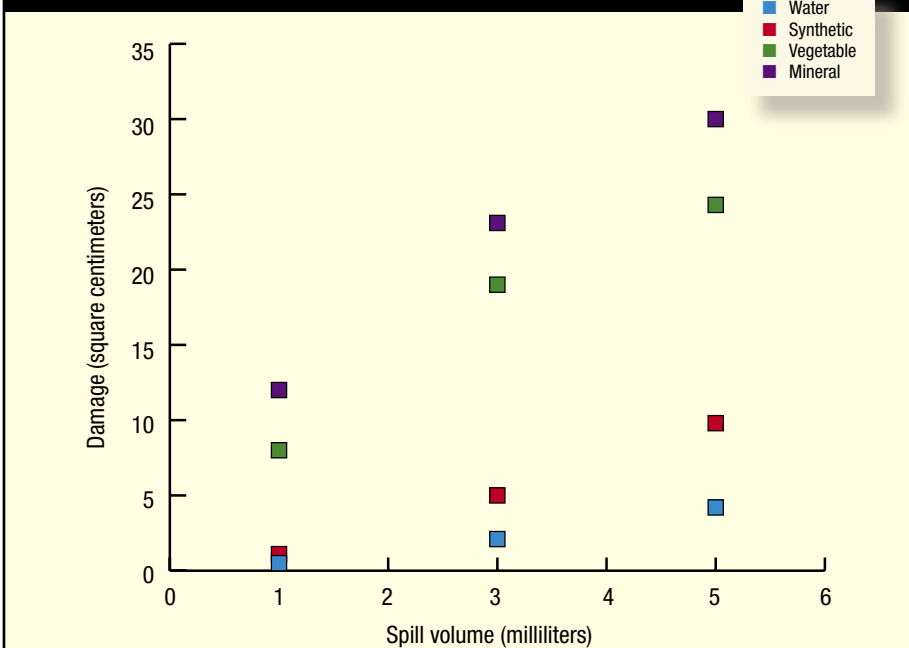


Figure 3. The effect of fluid type on the area of turf damage caused by the spill seven days after the spill occurred. The effects of fluids were examined across spill volumes averaged over fluid temperatures. Note that the petroleum oil and the vegetable oil produced the same basic response. Increasing the spill volume increased the area of damaged turf. The turf damage caused by the synthetic fluid was similar to that caused by water. Water = water; Synthetic = synthetic hydraulic fluid; Vegetable = vegetable/ester-based hydraulic oil; Mineral = petroleum/mineral-based hydraulic oil.

BURN INTENSITY

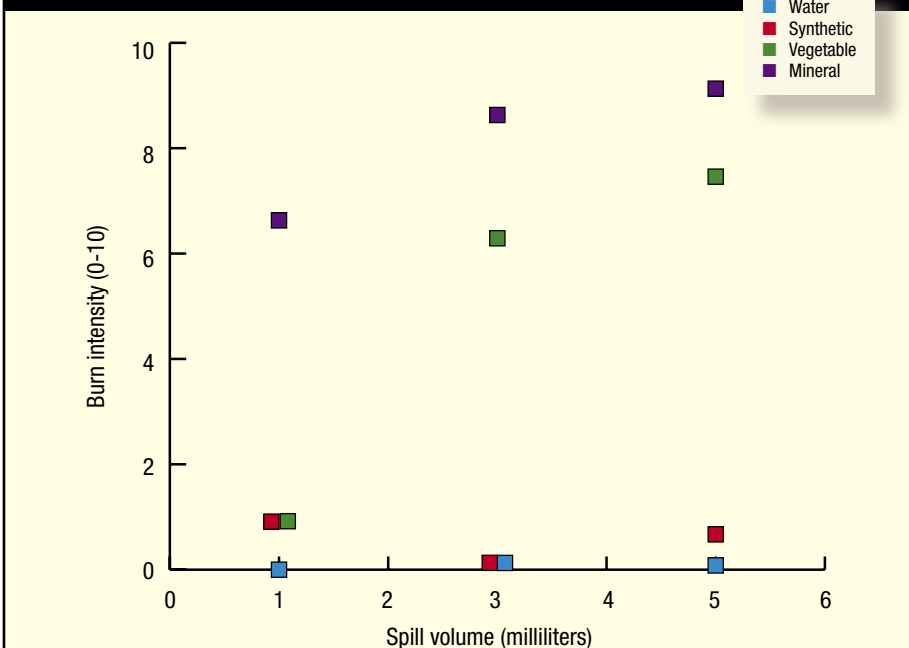


Figure 4. The effect of fluid type on burn intensity caused by the spill 28 days after the spill occurred. The effects of fluids were examined across spill volumes averaged over fluid temperatures. Note the lingering effect of both petroleum oil and vegetable oil. Spill volume appeared to be an important factor in sustaining the intensity of the burn resulting from the spill for both petroleum oil and vegetable oil. Water = water; Synthetic = synthetic hydraulic fluid; Vegetable = vegetable/ester-based hydraulic oil; Mineral = petroleum/mineral-based hydraulic oil.

hydraulic fluid from a triplex greensmower at operating temperature.

Fluids were heated to temperature in a glass beaker on a hot plate. The hot plate was adjacent to the putting green to ensure a minimal drop in the temperature of the fluids before release. Fluids were released onto the turf using a digital, single-channel, manual pipettor for volumes of 1-5 milliliters. The treatments were applied on May 15, 2006. Three hours after the last treatment was applied, the green was irrigated for five minutes at a rate of 137.6 gallons/minute (521 liters/minute).

This experiment was conducted as a randomized complete block design with three replications of each treatment.

Burn ratings were used in this study to compare treatment effects, where 0 = no burn and 10 = 100% turf death. Within each plot, the area of the turf that sustained visible injury from the spilled fluid was measured. After treatment, the plots were evaluated at seven-day intervals for 35 days for intensity of burn and the total area of visible turf damage.

Results

Day 7. By day 7 of the study, severe turf damage was visible where either petroleum/mineral- or vegetable/ester-based hydraulic oil had been released (Figure 3). Increasing the spill volumes of these hydraulic oils increased the size of the damaged area but did not increase the intensity of the burn. Increasing the temperature of these hydraulic oils did not increase either the area of injury or the intensity of the burn.

Both water and the synthetic hydraulic fluid also injured the turf, but to a lesser extent. Increasing the spill volumes of these fluids increased the area of turf damage and also increased the intensity of the burn. Increasing the temperature of the fluid did not significantly increase the area of damage, but it did result in a more intense burn.

Day 28. By day 28, visual inspection showed that all plots had recovered to some degree (Figure 4). However, plots treated with either the petroleum/mineral-based or the vegetable/ester-based hydraulic oil were still severely damaged, and the level of burn intensity was still comparatively high. Thus, the recovery rate for these plots appeared to be slower than for plots where the synthetic hydraulic fluid or water had been spilled. In contrast, by day 28, plots treated with either the synthetic hydraulic fluid or water showed

THE RESEARCH

says . . .

- **Spilling synthetic hydraulic** fluid causes significantly less damage to warm-season putting green turf than spilling biodegradable vegetable/ester-based or petroleum/mineral-based hydraulic oil.
- **In general, the** level of damage caused by any of the fluids tested depended at least partly on the nature of the fluid, the spill volume, the temperature of the fluid at the time of the spill, and the turf type the fluid was spilled on.
- **The vegetable/ester-based** hydraulic oil appeared to cause less damage to turf than the petroleum-based hydraulic oil in field conditions, but the effects of the vegetable/ester-based hydraulic oil were still devastating to the turf for a relatively long time.

minimal damage, if any, in terms of injury area or burn intensity.

This experiment showed that spilling the synthetic hydraulic fluid caused substantially less damage to the turf than either the petroleum/mineral- or the vegetable/ester-based hydraulic oil. The effect of the synthetic hydraulic fluid on turf was, throughout the course of the study, equivalent to spilling warm water.

Spill volume. Spill volume was a significant factor in causing turf damage for all fluids. As spill volumes increased, so did the area of damage and the intensity of the burn. This effect was more pronounced for the petroleum/mineral- and the vegetable/ester-based hydraulic oil than it was for the synthetic hydraulic fluid or water.

Fluid temperature. The temperature of the fluid at the time of the spill also appeared to be important for the synthetic hydraulic fluid and for water, but only in terms of burn intensity. The temperature of the fluid at the time of the spill did not seem to affect the amount of damage caused by the petroleum/mineral- or the vegetable/ester-based hydraulic oil. When the fluids were spilled at ambient temperatures, they readily damaged the turf, thus dispelling the myth that hydraulic fluids must be hot in order to kill or damage turf.

This experiment was repeated in January 2006 with statistically similar results.

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