Effect of Hydraulic Fluids on Warm Season Putting Greens

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Hydraulic systems are essential for the operation of many different types of golf course equipment. They enable many forms of precision mowing and make small tractors powerful and versatile. Hydraulics also help to make light weight spray rigs maneuverable and convenient to use, and they make mechanized bunker maintenance possible. The use of hydraulic power saves labor, increases productivity, and helps to generate a better quality golf course. But unfortunately, at this very moment somewhere in the world, some poor golf course superintendent has just had some prime turf ruined because hydraulic fluid has been spilled on it.

Above: (Photo 1) The effect of a hydraulic fluid spill on a hybrid bermudagrass putting green in southwest Florida. Right: (Photo 2) Repair of a hydraulic fluid spill on a 'Tifdwarf' putting green.

The release of hydraulic fluid onto a high-quality turf such as a putting green injures the turf to some degree. The extent of the turf injury may be dependent on turf type, the nature of the hydraulic fluid, the volume of fluid spilled, and on the temperature of the fluid at the time of the spill. And, there are probably many other factors as well. Hydraulic spills usually happen at the most inopportune times, and the resulting damage typically takes a relatively long time to heal. The release of hydraulic fluid onto a green also represents an environmental contamination event that is linked to equipment down-time and repair expense, as well as environmental pollution. Thus, the development of alternative hydraulic fluids that are non toxic to turf and that minimize the potential for environmental pollution would be highly desirable.

Research involving an alternative hydraulic fluid is now being conducted at Edison College in Fort Myers, Florida. A major objective of this research is to determine the extent of turf injury caused by the release of this fluid onto warm season putting greens and other high end turfs. Specific experimental factors that are being considered in the course of this research 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 initial experiments, including both lab experiments and field experiments, have now been conducted. In these initial experiments the effects produced by spills of the alternative fluid have been compared against effects produced by spills of industry standards. Specifically, we have to date examined four different kinds of hydraulic fluids spilled onto three different turf types at a variety of volumes and temperatures. By this article find a description of a portion of this research along with some of the preliminary results and conclusions.

A Container Study with 'Tifeagle'

The objective of this study was to determine the relative effect of four different hydraulic fluids spilled on containerized turf at ambient temperature.

This experiment began by establishing 'Tifeagle' bermudagrass (<u>Cynodon</u> <u>dactylon</u> L. [Pers.] x <u>C</u>. <u>transvallensis</u> Burt Davy) in PVC cores that were six inches tall and four inches in diameter in June, 2005. Cores were sealed at the bottom using plexiglass and adhesive. Each core had three 1/8 inch diameter holes drilled near the bottom for drainage. Within each core there was approximately one inch of clean gravel on the bottom covered by 3-4 inches of 90:10 greensmix. Four inch diameter plugs of 'Tifeagle' were then inset into each core. The turf was taken from an established 'Tifeagle' putting green located on the Lee County Campus of Edison College in Fort Myers, FL using a standard cup cutter. Prior to transplanting, the plugs were washed with water to remove existing soil and then extraneous root tissue was removed using shears. Clean, washed turf plugs were then set into each core so that the surface of the turf plug was about ½ inch below the rim of the core. Cores were then allowed to establish for ten days.

After the turf establishment period, 150 mLs of four different hydraulic fluids were spilled onto each of three cores. The fluids included conventional petroleum/mineral based hydraulic oil, biodegradable vegetable/ester based hydraulic oil, a newly developed synthetic poly-glycol based hydraulic fluid, and water. The experimental arrangement in this study was a completely random design with three replications. After the spills occurred each experimental core was evaluated for the effect of the fluid over a period of 10 days. Evaluations in this study included burn ratings, where 10 = severe burn and 0 = no burn. Cores were also evaluated for clipping yield ($g\ m^{-2}$) and for the chlorophyll content of the clippings (mg Chlorophyll A and B g^{-1} clippings). This study was repeated with similar results.

Photo. 3. The effect of hydraulic fluid spilled on 'Tifeagle' bermudagrass 10 days after the spill. WAT = water; SYN is the synthetic fluid; VEG is vegetable/ester based fluid; MIN is petroleum/mineral based fluid. Where water and the synthetic fluid were spilled turf was green and healthy. The other two fluids caused the death of the turf within 10 days.

All hydraulic fluids except water initially affected the quality of the 'Tifeagle.' After 2-3 days, the turf treated with either vegetable/ester oil or petroleum/mineral oil took on a darkened, oil-soaked appearance, followed by a matting of the turf, and eventual necrosis of the shoots. By day 10 of the study the turf had no green shoots, and was clearly dead (see Photo 3). There were no shoots to harvest, and as a result there was no chlorophyll to measure (see Table 1).

Table 1. Burn ratings from four types of hydraulic fluids spilled on containerized 'Tifeagle' bermudagrass. Spill volume was 150 mL, and the surface area of treated turf within containers was 81 cm^2. All fluids were spilled at ambient temperature, which was 33.3 °C. Spills occurred on 6/7/2005. Data on shoot yield and chlorophyll content of the clippings is also presented.

	Fluid				
	Synthetic	Vegetable	Mineral	Water	$lsd_{p = 0.01}$
4 dat[†]	4.0[‡]	7.0	8.0	0	< 0.1
5 dat	4.0	8.5	9.0	0	< 0.1
8 dat	2.5	9.0	9.0	0	< 0.1
10 dat	0	10.0	10.0	0	< 0.1
Shoots[§]	114	0	0	157	22 g m^{-2}
Chlorophyll[¶]	9.53	0.00	0.00	9.01	0.40 mg g^{-1}

[†] Days after treatment.

[‡] Burn/injury rating (10 = severe burn; 1 = no burn).

[§] Dry shoot yield at 10 dat (g m^{-2})

[¶] Mg chlorophyll A and B g^{-1} dried clippings.

In contrast, the turf treated with the synthetic fluid initially appeared burned or bleached to some degree, but the shoots remained upright and were observed to be turgid and resilient; by day 10 the turf appeared green and healthy with no visible signs of turf injury. Clipping yield was reduced compared to where water had been applied, but turf treated with the synthetic fluid had more chlorophyll and was thus a bit greener.

When the cores were dismantled for an internal examination it was apparent that the soil contained within cores treated with vegetable/ester oil or petroleum/mineral oil was contaminated and fouled. The soil smelled like oil and had a greasy, oily feel. It was also visibly apparent that existing roots died and new root development was seriously inhibited (see Photo 4).

Photo 4. The effect of surface applied hydraulic fluids on root development in 'Tifeagle' 10 days after treatment. The turf treated with vegetable/ester oil (Veg) or petroleum/mineral oil (Min) had no viable roots emerging from the bottom side of the thatch, while turf treated with synthetic fluid (Syn) had an abundance of white, viable roots.

Soil contained within cores treated with the synthetic fluid did not exhibit any kind of oily smell or feel. The soil maintained its earthy smell, and color, and there was an abundance of white, viable roots that were clearly visible.

From the results of this initial study it was concluded that the poly-glycol based 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 oil when spilled onto 'Tifeagle' bermudagrass turf.

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 at ambient temperature on three different warm season turfs maintained as putting greens.

This experiment began by establishing experimental plots on three separate warm-season putting greens located on the Lee County Campus of Edison College in Fort Myers, FL, in October, 2005. Turf on green #1 was 'Tifeagle' hybrid bermudagrass (*Cynodon dactylon* L. [Pers.] x *C. transvallensis* Burt Davy), while the turf types on greens 2 & 3 were 'Sea Isle I' seashore paspalum (Paspalum vaginatum O. Swartz) and 'Tifdwarf' hybrid bermudagrass (Cynodon dactylon L. [Pers.] x C. transvallensis Burt Davy), respectively.

Greens were constructed in September, 2003 according to United States Golf Association specifications. Supporting greensmix was 90:10 sand:peat by volume mixed offsite. The greens were mowed daily with a triplex greens mower equipped with 11 blade reels and tournament bedknives and bench-set at 0.38 cm. The greens were fertilized using a greens grade 10-2-20 at a basic rate of ½ lb. of N per 1,000 sf every 2 weeks, and were irrigated as necessary.

Experimental plot size was 12" x 12", providing for a surface area inside each plot of 1 sf. Treatments for this study consisted of a poly-glycol based synthetic hydraulic fluid, biodegradable vegetable/ester based hydraulic oil, petroleum/mineral based hydraulic oil, and water, which served as a control. Experimental design was a randomized complete block with four replications. Treatments were arranged as a 4 x 3 factorial for analysis purposes, with factors being turf type and hydraulic fluid type.

In this study treatments were applied to the turf using a plastic syringe. The volume of each fluid spilled was 20 mL with fluids at ambient temperature. Fluids were spilled in straight lines within the confines of each plot through the center of each plot, so as to simulate fluid leaking from a machine in operation. No washing occurred and no irrigation was applied within 8 hours of treatment application.

After the treatments had been applied, each set of plots was evaluated at 5, 15, and 30 days after treatment for turf injury in terms of burn and area of injury (see Photo 5 and Table 2).

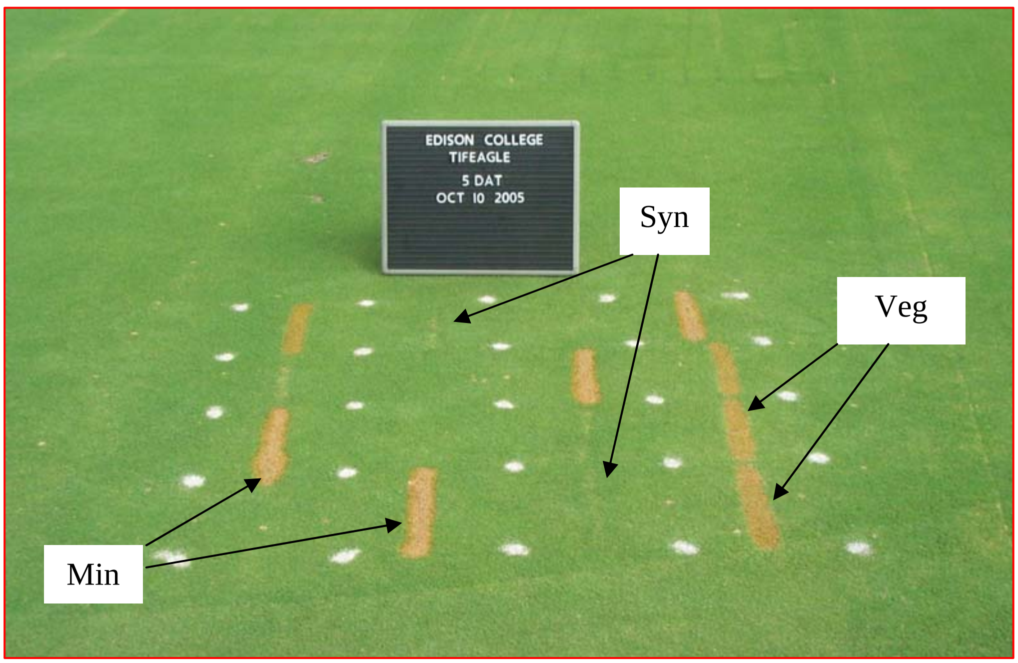

Photo 5. The effect of hydraulic fluids spilled on 'Tifeagle' hybrid bermudagrass 5 days after treatment. Both vegetable/ester based oil (Veg) and the petroleum/mineral based oil (Min) readily killed turf. The synthetic fluid (Syn) burned the turf slightly. The volume of each spill including the synthetic was 20 mL.

Table 2. Area of turf injury and burn ratings from three types of hydraulic fluids spilled on three different warm season turfgrass cultivars maintained at 0.150”. Spill volume was 20 mL per spill. Plot size was 1 sf. All fluids spilled were at ambient temperature, which was 29.4 °C. Spills occurred on 10/5/2005.

			Cultivar			
	Fluid		Tifdwarf	Tifeagle	Sea Isle I	lsd $_{P = 0.01}$
5 dat[†]	Synthetic	Injury Area[‡]	52	47	47	30 cm^2
		Burn Rating[§]	2.1	1.6	1.3	0.3
	Vegetable	Injury Area	233	145	75	
		Burn Rating	10.0	10.0	4.0	
	Mineral	Injury Area	266	190	92	
		Burn Rating	10.0	10.0	10.0	
	Control	Injury Area	0.0	0.0	0.0	
		Burn Rating	1.0	1.0	1.0	
15 dat	Synthetic	Injury Area	0.0	0.0	0.0	29 cm^2
		Burn Rating	1.0	1.0	1.0	0.5
	Vegetable	Injury Area	206	144	55	
		Burn Rating	10.0	10.0	5.7	
	Mineral	Injury Area	266	204	116	
		Burn Rating	10.0	10.0	10.0	
	Control	Injury Area	0.0	0.0	0.0	
		Burn Rating	1.0	1.0	1.0	
30 dat	Synthetic	Injury Area	0.0	0.0	0.0	26 cm^2
		Burn Rating	1.0	1.0	1.0	< 0.1
	Vegetable	Injury Area	191	144	29	
		Burn Rating	10.0	10.0	4.0	
	Mineral	Injury Area	257	210	113	
		Burn Rating	10.0	10.0	10.0	
	Control	Injury Area	0.0	0.0	0.0	
		Burn Rating	1.0	1.0	1.0	

[†] Days after treatment.

[‡] Area of turf injured by each spill (cm^2).

[§] Burn rating (10 = severe burn; 1 = no burn).

By day 5 it was obvious that the turf treated with the vegetable/ester based oil and the petroleum/mineral based oil was burned severely. These two hydraulic fluids consistently produced larger areas of turf damage with more intense burn for the 20 mL spill than did the synthetic fluid. This was true for all turf types. By 15 days after treatment the plots where synthetic fluid had been spilled had healed completely. Again, this was true for all turf types.

Two very interesting trends emerged from this data. First, it was apparent that 'Tifdwarf' had larger areas of turf damage for the given volume of vegetable oil or petroleum oil than did 'Tifeagle.' And 'Tifeagle' had larger areas of turf damage for the given volume of oil than did the seashore paspalum. Second, the seashore paspalum was damaged much less by the given volume of vegetable oil than it was by the petroleum based oil. Still, the synthetic fluid caused the least turf damage for all turf types.

Interestingly, where vegetable oil was spilled on 'Tifdwarf' the healing process seemed to begin by 30 days after the spill but the effect of petroleum oil lingered. For 'Tifeagle' the effect of the vegetable oil lingered and the effect of the petroleum oil actually increased. For the seashore paspalum the healing process for vegetable oil began relatively quickly, but the effect of the petroleum oil seemed to increase and linger.

From the results of this field study it was concluded that the poly-glycol based synthetic hydraulic fluid caused substantially less turf injury in terms of the area of turf damaged and the associated degree of burn than the biodegradable vegetable/ester based hydraulic oil or petroleum/mineral based hydraulic oil. The petroleum oil appeared to cause larger areas of turf damage for a given amount than did the vegetable oil. The 'Tifdwarf' appeared to be impacted more than the 'Tifeagle' while seashore paspalum was impacted the least.

In conclusion, these two studies have demonstrated that a spill of the new synthetic poly-glycol based hydraulic fluid causes less damage to turf than a spill of either vegetable/ester based hydraulic oil or petroleum/mineral based hydraulic oil. Photos 3 and 5 provide great evidence of that. Vegetable oil appeared to cause less damage to turf than the petroleum oil in field conditions, but the effects of the vegetable oil, at the rates applied, were still devastating to the turf for a relatively long period of time. Of major importance to consider is that none of the hydraulic fluids spilled in this portion of the research were hot. In these studies, the oils were spilled at ambient temperatures, effectively dispelling the myth that hydraulic fluids must be hot to kill or damage turf. Other experiments currently being conducted at Edison College are directly examining the influence of both fluid temperature and spill volume. Those results are to be presented in the very near future.

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