Comparison of Damage to 'Tifgreen' Bermudagrass by Petroleum and Vegetable Oil Hydraulic Fluids

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Additional index words. *Cynodon* spp., *golf courses, turfgrass equipment*

Summary. Petroleum and vegetable oil hydraulic fluids were spread on 'Tifgreen' bermudagrass at three volumes (125, 250, and 500 ml) and three temperatures (27, 49, and 94C) to simulate a turfgrass equipment leak. Initial damage, recovery, and effects for a l-year period were compared among treatments. All hydraulic fluid treatments resulted in 100% leaf necrosis within 10 days of application. Turfgrass recovery was influenced primarily by the fluid volume. After recovery, only plots treated with petroleum hydraulic fluid were periodically chlorotic, resulting in lower turfgrass quality. Long-term negative effects of hydraulic leaks from golf course equipment may be reduced by using vegetable oil hydraulic fluid.

Mowers and other turf equipment used to maintain golf courses often have a hydraulic mechanism. Leaks of hydraulic fluid commonly damage turfgrass and are especially visible on putting greens and tees. Depending on the amount of fluid leaked, immediate damage ranges from chlorosis to necrosis of leaf tissue (Johns and Beard, 1979; personal observations). After recovery from this initial damage, these turf areas commonly exhibit secondary symptoms (usually chlorosis) when the playing surface is stressed in the following months or years.

An alternative to presently used petroleum-based hydraulic fluid is vegetable oil hydraulic fluid. The latter is readily biodegradable and nontoxic, yet it provides the proper lubrication for operation of equipment (Cheng et al., 1991). The objective of this research was to compare the effect of petroleum and vegetable oil hydraulic fluids on 'Tifgreen' bermudagrass [*Cynodon dactylon* (L) Pers. × *C. transvaalensis* Burtt-Davy] after a leak was simulated.

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Materials and methods

An experiment was initiated in 1993 at the Fort Lauderdale Research and Education Center on established 'Tifgreen' bermudagrass maintained at 6.25mm by mowing three times weekly. The turf was irrigated as needed and was fertilized with 0.1 kg N/m^2 per year. Plots measuring 7.5 × 120 cm were spaced 30 cm apart. Treatments included an untreated control, a petroleum hydraulic fluid (Mobil DTE 26) composed of 95% petroleum distillates, and a vegetable oil hydraulic fluid (Mobil EAL 224H) composed of 98% vegetable oil (Mobil Oil Corporation, Princeton, N.J.). Each fluid was applied in three volumes (125, 250, and 500 ml) and at three temperatures (27, 49, and 94C). Fluids applied at 49 and 94C were. heated on site. These temperatures were selected as they had been used previously for evaluating performance of hydraulic fluid in operating equipment (Cheng et al., 1994). The ambient temperature was 27C.

Hydraulic fluid treatments were applied 29 Mar. 1993 by pouring the fluid directly on the plots and immediately spreading with a 7.5-cm paintbrush, presaturated with hydraulic fluid. All treatments were replicated four times in a randomized complete-block design. The plots were monitored daily for leaf chlorosis and necrosis from 29 Mar. through 7 Apr. 1993. Plots then were monitored weekly for recovery from the treatments through August 1993 and thereafter for quality (primarily chlorosis and necrosis) until the experiment was terminated 18 Apr. 1994, when a final quality evaluation was made.

Results and discussion

Within 24 h after the hydraulic fluid was applied on 29 Mar. 1993, partial leaf necrosis was observed in plots treated with both hydraulic fluids heated to 94C and for all the other petroleum hydraulic fluid treatments. Other vegetable oil hydraulic fluid treatments did not cause tissue necrosis at this time, but the plots were distinctly different in color (light green) from the check strips, which had a normal green color. After 48h, all the plots treated with petroleum hydraulic. fluid exhibited complete leaf necrosis. Plots treated with vegetable oil hydraulic fluid required an additional 5 days before they also exhibited complete leaf necrosis. By 7 Apr. 1993, only the control plots remained healthy and green, whereas all other plots exhibited complete leaf necrosis (Fig. 1).

All plants in the hydraulic-fluid-treated plots died, and recovery was due to growth of bermudagrass stolons from outside the necrotic turfgrass plots to the interior. Plots were rated for recovery based on turfgrass coverage on 25 May and 30 June 1993. There was no significant interaction for recovery between type, volume, and temperature of the fluids at application (Table 1). Significant differences were

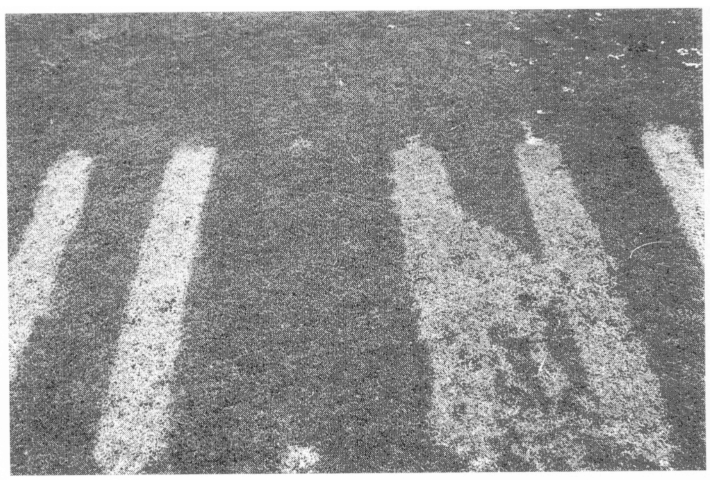

Fig. 1. ***Effects of vegetable oil and petroleum hydraulic fluid treatments on 'Tifgreen' bermudagrass 9 days after the fluid was applied on 29 Mar. 1993. Lines 1,2, and 6 were treated with 27C vegetable oil hydraulic fluid at 125-, 500-, and 250-ml volumes, respectively; line 3 was a control treatment; Lines 4 and 5 were treated with 49C petroleum hydraulic fluid at 500- and 250-ml volumes, respectively.***

Table 1. *Effects of petroleum and vegetable oil hydraulic fluids applied 29 Mar. 1993 to 'Tifgreen' bermudagrass.*

Volume (ml)	Temp (°C)	Turfgrass coverage[z](%) 25 May 1993	Turfgrass coverage[z](%) 30 June 1993	Quality rating[y] 4 Jan. 1994	Quality rating[y] 18 Apr. 1994
Petroleum					
125	27	65	97	5.8	8.0
125	49	58	99	5.8	6.8
125	94	60	99	6.0	8.0
250	27	28	86	3.3	3.5
250	49	23	95	2.8	4.3
250	94	23	89	2.8	4.8
500	27	10	53	2.5	3.8
500	49	10	80	2.0	3.5
500	94	10	70	2.0	4.3
Vegetable oil					
125	27	55	87	7.0	8.0
125	49	80	94	7.0	8.0
125	94	78	91	7.0	8.0
250	27	43	85	7.0	8.0
250	49	28	74	7.0	8.0
250	94	38	80	7.0	8.0
500	27	9	59	7.0	8.0
500	49	9	46	7.0	8.0
500	94	9	66	7.0	8.0
Mean significant difference ($P = 0.05$)		16	44	1.3	1.7
Significance of factorial effects (F test)					
Fluid (F)		*	NS	***	***
Volume (V)		***	***	***	***
Temperature (T)		NS	NS	NS	NS
F × V		NS	NS	***	***
F × T		NS	NS	NS	NS
V × T		NS	NS	NS	NS
F × V × T		NS	NS	NS	NS

[z]*On 7 Apr. 1993, all plots had completely necrotic leaves except for the control plots, which were undamaged. Values are means of four replicate plots. Mean separation in columns by Waller–Duncan k ratio* t *test.*
[y]*Quality ratings were based on a scale of 1 (poor quality) to 10 (best quality). Mean quality ratings of control plots were 7.0 and 8.0 on 4 Jan. 1994 and 18 Apr. 1994, respectively. Values are means of four replicate plots. Mean separation in columns by Waller–Duncan k ratio* t *test.*
[NS],*,*** *Nonsignificant or significant at* $P \leq 0.05$ *or 0.001, respectively.*

observed on both dates from varying volumes of hydraulicfluid.A significant difference in recovery due to fluid type existed, but only on 25 May. At that time, a common weed, prostrate spurge [*Chamaesyce maculata* (L.) Small], which establishes from seed, was observed growing in the vegetable oil hydraulic-fluid-treated plots and perhaps competing with the bermudagrass. This weed did not grow in the plots treated with petroleum oil hydraulic fluid. A herbicide (metsulfuron) was applied uniformly to all plots to eliminate the weed.

All plots had at least 80% recovery by 31 July and complete recovery by 1 Sept., with the exception of three plots treated with 500 ml petroleum hydraulic fluid (data not presented).

No other differences were observed until 4 Jan. 1994 when some plots developed a general leaf chlorosis (Table 1). This chlorosis, associated only with the petroleum hydraulic fluid plots, decreased turfgrass quality. However, only the larger two volumes (250 and 500 ml) of the petroleum hydraulic fluid significantly decreased quality ratings. The chlorosis was observed periodically during the remaining months in the 1-year monitoring period and was associated only with grass plots treated with petroleum hydraulic fluid. When the experiment was terminated in Apr. 1994, leaf chlorosis was still associated with the petroleum hydraulic fluid treatments (Table 1).

These results show that different compositions, volumes, and temperatures of hydraulic fluids ultimately had the same short-term effect on the grass—death of the plant. The potential short-term toxicity of petroleum hydraulic fluid was illustrated also by the killing of the prostrate spurge weed seeds in plots treated with this material but not in the plots treated with vegetable oil hydraulic fluid. Fluid volume, for both types of hydraulic fluids, influenced recovery (i.e., turfgrass coverage) more than any other factor.

The potential for prolonged effects of the petroleum hydraulic fluid on the turfgrass was evident based on the leaf chlorosis and decreased turfgrass quality that developed periodically in association with this fluid only, even at the low-level volume. Therefore, by using the vegetable oil hydraulic fluid in golf course equipment, long-term negative effects on the turfgrass may be reduced when a hydraulic leak occurs. This is probably due to the fact that with the vegetable oil hydraulic fluid used in this study, there is >60% carbon degradation to CO_2 in 28 days (Mobil Oil Corp., 1991). This also allows for small spills of this fluid to be readily biodegraded by naturally occurring soil organisms when exposed to air.

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