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UV-B Filtration to Reduce Photolysis of Fluridone in Experimental Tanks[1]

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INTRODUCTION

Fluridone (1-methyl-3-phenyl-5-[3-(trifluromethyl)-phenyl]-4-(1H)-pyridinone), is the active ingredient in the aquatic herbicide Sonar®, which is registered by US EPA for the control of hydrilla [*Hydrilla verticillata* (L.f.) Royle] and other submersed species. Efficacy of fluridone is highly dependent on exposure time and concentration (Van and Conant 1988, Netherland et al. 1993). Fox et al. (1994) developed a fluridone exposure days (FED's) concept that predicts the efficacy of fluridone on hydrilla in relation to exposure time and concentration and indicates that continuous fluridone exposure (10 to 15 ppb) over an 8 to 10 week period is required to control hydrilla.

Fluridone is degraded through both photolytic (Mossler et al. 1989) and microbial (Mossler et al. 1991) mechanisms. Ultraviolet radiation in the range of 300 to 320 nm is termed UV-B radiation, while UV-A wavelengths are between 320 and 380 nm (Bartholic et al. 1974). Mossler et al. (1989) reported the half-life of fluridone in glass containers under full sunlight conditions (1800-2100 µmol/m^2/sec) was 15-36 hrs under wavelengths of 297 to 325 nm (UV-B), and up to 840 hours under wavelengths of 326 to 355 nm (UV-A), respectively.

Although fluridone has provided submersed weed control in natural waters, results from experimental tanks and pools have not been as effective. Wells et al. (1986) evaluated fluridone efficacy against several submersed aquatic plants as part of the registration of fluridone for aquatic weed control in New Zealand. These studies, largely conducted in shallow outdoor tanks, included fluridone concentrations of up to 10 mg l^{-1}. Results from this study concluded that fluridone was an ineffective herbicide. Results obtained with fluridone in semi-controlled conditions (glass jar tests, shallow tanks, etc.) have not been reliable indicators of fluridone efficacy under natural conditions (D. Tarver, Pers. Comm.). These contrasting results may result from reduced plant growth under experimental conditions or rapid fluridone degradation by photolysis in shallow experimental vessels. The photolysis of fluridone has not been studied over the several week periods believed required for weed control, thus, the objective of this study was to evaluate the impact of UV-B radiation on fluridone degradation in shallow experimental tanks.

MATERIALS AND METHODS

Studies were conducted at the Center for Aquatic Plants in Gainesville, FL where technical grade fluridone[4] was added to six 950 L (217 cm-length × 76 cm-width × 57 cm-depth) concrete vaults on June 20, 1993 to establish a concentration of 850 ppb in each vault. The vaults were filled with well water and kept at a constant volume throughout the study.

Three vaults were covered with a clear ultraviolet-B protective film[5] to absorb ultraviolet light radiation below 320 nm. The 4 mil clear polyester film, obtained in rolls 30.5 m long and 1 m wide, was tacked to wooden frames that covered the edges of the vaults with a raised board down the center of the frame to allow rain water to drain off the film. The combination of the frame and the film reduced light (PAR) penetration in the covered tanks by 25%. Condensation on the inside of the film was prevented by placing bricks under the frames to allow air circulation between the frames and the edges of the vault. The remaining three vaults were left uncovered.

Water samples (200 ml) were taken from each vault before the addition of fluridone, immediately after treatment and approximately once a week for 8 weeks. Samples were frozen and stored at -20 C prior to analysis.

Fluridone content of the water was determined by the extraction procedure described in Fox et al. (1991) and by high performance liquid chromatography (HPLC). Samples were analyzed using a 15-cm × 4.6 mm Supelco[6] LC18-DB column (nominal particle size 5.0 µm) with a 40:60 acetonitrile:water mobile phase and flow rate of 0.75 ml/minute. Retention time for fluridone was 14 to 14.5 minutes. Detection of fluridone was accomplished using a UV-visible detector[7] set at 300 nm (0.005 AUFS). The concentrations of fluridone in the supernatant were calculated using known standard concentrations.

The absorbance characteristics of the filter wrap (Figure 1a) were determined spectrophotometrically[8]. This film is reportedly highly absorbent in the UV-B radiation range, absorbing wavelengths <320 nm which have been shown to

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[4]DowElanco, Inc., Indianapolis, IN 46268.

[5]Mylar® Polyster Type D film, Stock 06720, Transilwrap Company, Inc. 3616 McCall Place, Doranville, Georgia 30340.

[6]Supelco, Inc., Bellefonte, PA 16823.

[7]Perkin-Elmer Corp., Norwalk, CT 06856.

[8]Shimadzu Model UV160, Shimadzu Corp.

be primarily responsible for the photolytic breakdown of fluridone (Mossler et al. 1989). Any degradation of fluridone under filtered conditions thus should be due to UV-A photolytic decomposition or other degradation mechanisms. The amount of fluridone degradation in filtered tanks should also have occurred in the unfiltered vaults, with the difference in fluridone dissipation between these two conditions providing a measure of the amount of UV-B photolytic breakdown. This photolytic decomposition was calculated using the following formula: %UV-B degradation = (% unfiltered/(% filtered - % unfiltered)/100).

Fluridone dissipation was calculated as the percent of initial fluridone concentration present in the vaults immediately after fluridone application. Data were subjected to analysis of variance to test for treatment effects (filtration and weeks after treatment) and interactions. Regression analysis was used to determine the rate of fluridone dissipation and to determine half-life values. Data are presented with standard errors.

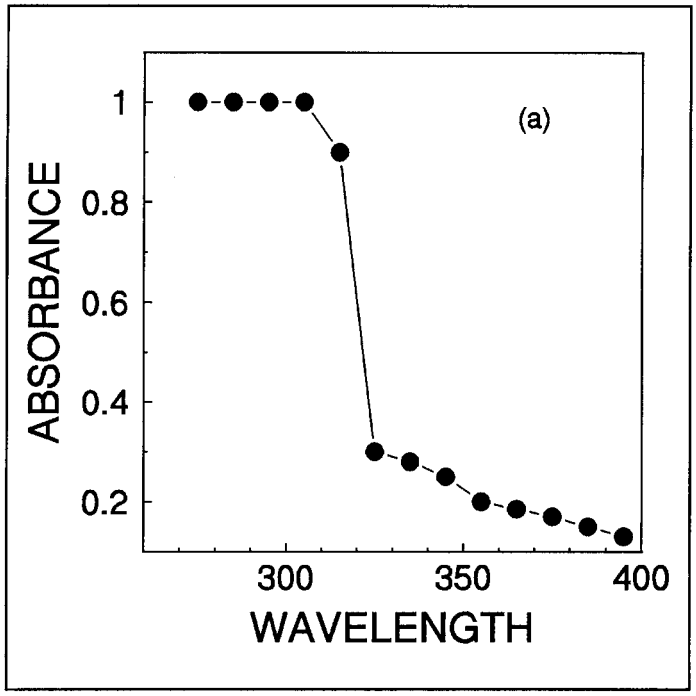
RESULTS AND DISCUSSION

There was a significant effect ($P < 0.05$) of filtration and weeks after treatment but no interaction occurred between the two parameters. Fluridone dissipation under UV-B filtered conditions was much less than unfiltered conditions and decreased linearly over time (Figure 1b). Fluridone exposed to unfiltered sunlight conditions degraded at an exponential rate and was undetectable at the completion of the study.

Many researchers have demonstrated rapid photolytic fluridone breakdown under experimental conditions. Saunders and Mosier (1983) reported a half-life of 28 to 55 hours in deionized water, while the half-life in lake water was 12 days. Further characterization by Mossler et al. (1989) reported a half-life of 26 hours in distilled water under UV-B conditions (297-325 nm). In this study, the half-life of unfiltered fluridone was approximately 7 days. The half-life values in our study are similar to the aforementioned studies and indicate that fluridone degradation in the unfiltered vaults was primarily due to photolytic breakdown from UV-B radiation. The predicted fluridone half-life from UV-B radiation alone was 9 days. This was calculated from the following regression equation: $y=50*(\exp^{0.77x})$ $R^2 = 0.99$, which was derived from the difference between unfiltered and filtered fluridone dissipation.

Fluridone in the filtered (UV-B protected) vaults had a half-life of 33 days which is much less than reported for other fluridone microbial degradation half-life values. Although microbial degradation of fluridone has been reported under natural conditions (Banks and Merkle, 1978, Mossler et al., 1991), the rapid decrease in fluridone concentration in this study does not fit this scenario. Degradation of fluridone was probably due to UV-A radiation since the half-life is similar to that found in previous studies. Mossler et al. (1989) demonstrated limited degradation of fluridone under UV-A radiation (specifically 325-355 nm) with a half-life of 840 hours or 35 days. The predicted half-life value in our study was 33 days, indicating UV-A radiation was primarily responsible for the decrease in fluridone concentration under our filtered conditions.

Results from this study provide evidence that the primary loss of fluridone was due to photolytic breakdown from UV-B radiation.



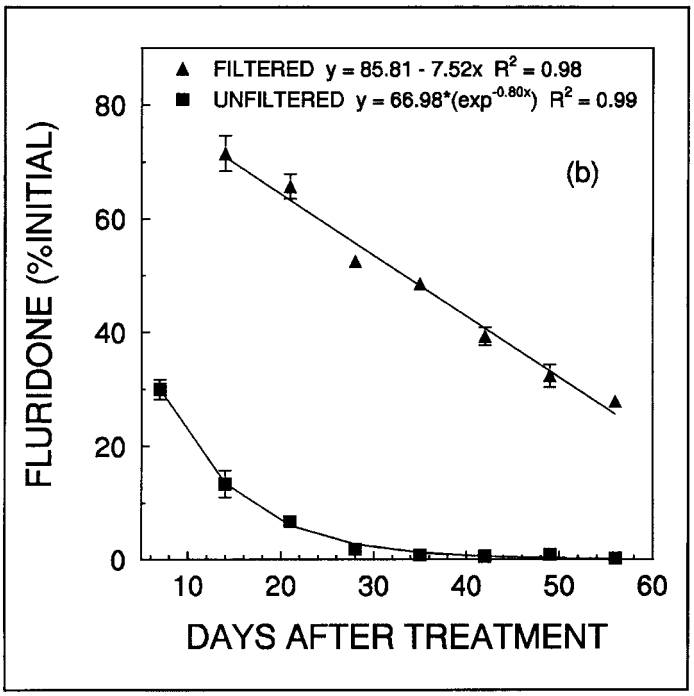


Figure 1a (top). The absorbance of Transil Wrap filter used to limit UV-B radiation from entering tank water, and Figure 1b (bottom). The effect of UV-B filtration on the dissipation of fluridone from water in shallow, concrete outdoor tanks.

The half-life of fluridone in natural waters varies widely depending upon water depth, plant coverage, water clarity and other factors which affects photolytic degradation. The manufacturer (SePro, Inc.) reports typical half-lives of fluri-

done in water of 5 to 60 da, however Fox et al. (1996) have reported a half-life of 90 days in large scale lake treatments incorporating both liquid and pellet fluridone formulations.

The half-life of fluridone in shallow experimental tanks is much shorter than is typically encountered in field conditions. This study shows that protecting fluridone by UV filters, slows the degradation of fluridone and the resulting half-life of the herbicide is more similar to field studies.

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LITERATURE CITED

Banks, P. A. and M. G. Merkle. 1978. Effectiveness and persistence of fluridone. Proc. South. Weed Sci. Soc. 31: 74.

Bartholic, J. F., F. H. Halsey and R. H. Biggs. 1974. Effects of UV radiation on agricultural productivity. Third Conf. of CIAP. U.S. Dept. Trans. Wash. D.C. pp. 498-504.

Fox, A. M., W. T. Haller and D. G. Shilling. 1991. Correlation of fluridone and dye concentrations in water following concurrent application. Pestic. Sci. 31: 25-36.

Fox, A. M., W. T. Haller and D. G. Shilling. 1994. Use of fluridone for hydrilla management in the Withlacoochee River, Florida. J. Aquat. Plant Manage. 32: 47-55.

Fox, A. M., W. T. Haller and D. G. Shilling. 1996. Hydrilla control with split treatments of fluridone in Lake Harris, Florida. Special Edition, Pro. EWRS 9th Aquatic Weeds Symposium, Hydrobiologia: (In Press).

Mossler, M. A., D. G. Shilling and W. T. Haller. 1989. Photolytic degradation of fluridone. J. Aquatic Plant Manage. 27: 69-73.

Mossler, M. A., D. G. Shilling, S. L. Albecht and W. T. Haller. 1991. Microbial degradation of fluridone. J. Aquatic Plant Manage. 29: 77-80.

Netherland, M. D., K. D. Getsinger and E. G. Turner. 1993. Fluridone concentration and exposure time requirements for control of Eurasian watermilfoil and hydrilla. J. Aquatic Plant Mange. 31: 189-194.

Saunders, D. G. and J. W. Mosier. 1983. Photolysis of the aquatic herbicide fluridone in aqueous solution. J. Agric. Food Chem. 31: 237-241.

Van, T. K. and R. D Conant Jr. 1988. Chemical control of hydrilla in flowing water: herbicide uptake characteristics and concentration versus exposure. Technical Report A-88-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 48 p.

Wells, R. D. S., B. T. Coffey and D. R. Lauren. 1986. Evaluation of Fluridone for Weed Control in New Zealand. J. Aquat. Plant Manage. 24: 39-42.