J. Aquat. Plant Manage. 47: 63-65

Residue Profile and Efficacy Comparisons between Two Liquid Formulations of Fluridone

BRETT W. BULTEMEIER, A. PURI, W.T. HALLER[1] AND V.V. VANDIVER, JR.[2]

INTRODUCTION

Fluridone {1-methyl-3-phenyl-5-[3-(trifluoromethyl) phenyl]-4(1H)-pyridinon} (Sonar®AS[3]) (hereafter AS) was registered in 1986 and is widely used to control submersed aquatic vegetation. It effectively controls several submersed weeds at low concentrations (5-20 ppb), but requires weeks of exposure time to be effective (Fox et al. 1994; Netherland and Getsinger 1995; Netherland et al. 1993; Poovey et al. 2005). Lethal doses of fluridone can be achieved by applying an initial rate high enough to sustain toxic concentrations, through the use of controlled release formulations (Koschnick et al. 2003), or by applying additional treatments over time to maintain required concentration/exposure times (Getsinger et al. 2002; Poovey and Getsinger 2005). For example, Netherland et al. (1993) reported that concentrations of fluridone at ≥12 µg a.i. (active ingredient) L^{-1} likely need to be maintained for > 60 d for adequate hydrilla control. Knowledge of the degradation profile of fluridone is necessary to ensure lethal concentration/exposure times for aquatic weed control. Residue information became readily available in the mid-90's with the development of an enzyme linked immunoassay (ELISA) method, which allows rapid and accurate measurements of fluridone concentrations in the water (Getsinger et al. 2008).

Previous studies report fluridone half-lives (the amount of time required for 50% of a herbicide to be degraded from the environment) ranging from 5-60 d with an average half-life of 21 d (Osborne et al. 1989; West et al. 1983). Fluridone degrades due to photolysis, so depth, water clarity and light penetration can all influence the half-life of fluridone in water (Mossler et al. 1989; West et al. 1983). Previous reports have analyzed degradation/release profiles and efficacy of different granular fluridone formulations and found no differences between them (Koschnick et al. 2003). New liquid formulations of aquatic herbicides are being introduced to the aquatic market, but the question persists as to whether these different formulations are similar. Therefore, an understanding of the efficacy and degradation in treated waters of the new formulations (WHITECAP™ SC[4] (hereafter SC)) is necessary to determine if new treatment protocols should be developed relative to formulation. In this study, the degradation profile of two liquid formulations of fluridone (AS and SC) was examined in ponds and the efficacy of these formulations was assessed on hydrilla in mesocosms.

MATERIALS AND METHODS

Residue Study

Four static ponds were treated with a target concentration of 50 µg a.i. L^{-1} fluridone with either the AS or SC formulations (two ponds per formulation). Fluridone was applied using weighted trailing hoses to ensure uniform mixing within the water column. Pond C (0.54 ha, average depth 1.22 m) is located in Okeechobee County, FL and was entirely covered with *Landoltia* sp. (duckweed) when treated with AS on September 26, 2007. Ponds 5, 6 and 7 were 0.28 ha, with an average water depth of 1.1 m and were heavily infested with *Chara* sp. (muskgrass) and hydrilla when treated on September 27, 2007. Pond 7 and C were treated with the AS formulation while ponds 5 and 6 were treated with the SC formulation.

Water samples for fluridone residue analysis were collected weekly for 26 wks beginning 7 days after treatment (DAT). Water samples were collected 0.3 m below the surface of the water, at three fixed locations in each pond, in amber high-density polyethylene (HDPE) bottles and were kept on ice during transport to a freezer. Frozen water samples were sent to EnviroLogix Inc.[5] for fluridone analysis using ELISA with a limit of detection of 0.5 ppb with 88% recovery.

Residue data for all four ponds were subjected to analyses of variance and no differences were found, so data for ponds 7 and C (AS) were pooled as were data for ponds 5 and 6 (SC). Pooled data were then subjected to regression analysis from 7-182 DAT to determine the degradation profile for both formulations.

Hydrilla Efficacy Study

The efficacy of fluridone (AS and SC) on hydrilla was examined in mesocosm studies at the UF-IFAS Center for Aquatic and Invasive Plants (CAIP) in July–September 2007. Five 10 cm long sprigs of hydrilla were planted in four pots (11 × 11 × 13 cm), which were placed in 95 L tanks (60cm diameter and 46cm deep) that contained 74 L of water. Each tank was one replication and each treatment was replicated four times. Plants were allowed 3 wk to establish before treatment with 0, 5, 15, 25, 50 or 100 µg L^{-1} of fluridone AS or SC.

[1]University of Florida Department of Agronomy and Center for Aquatic and Invasive Plants. 7922 NW 71[st] St. Gainesville, FL. 32653.

[2]Vandiver Consultants Corp. 9715 NW 63[rd] Ln. Gainesville, FL. 32653-6808. Corresponding author's e-mail: bwbult@ufl.edu.

[3]SePRO Corporation. 11550 North Meridian St. Carmel, IN, 46032.

[4]Tessenderlo Kerley, Inc. 2255 North 44[th] St, Suite 300. Phoenix, AZ, 85008.

[5]EnviroLogix Inc. 500 Riverside Industrial Parkway, Portland, ME 04103-1486. Received for publication August 30, 2008 and in revised form January 7, 2009.

Plant shoots were harvested 8 wk after treatment (WAT), and oven-dried at 70 C to determine remaining biomass. Regression analysis (exponential decay $y = c + ae^{bx}$) was used to calculate the EC_{50} of each formulation and 95% confidence intervals for each EC_{50} (the effective fluridone concentration required to reduce plant biomass by 50% compared to an untreated control) was used to compare the two formulations.

RESULTS AND DISCUSSION

Residue Study

There were no significant differences in the concentration of fluridone detected 7 DAT for AS (19 µg a.i. L^{-1} (95% CI = 18-21)) and SC (26 µg a.i. L^{-1} (21-30)) formulations. However, these data are significantly less than the target concentration of 50 µg a.i. L^{-1} that was theoretically applied at time of treatment. The reason for this significant difference is not clear, but other studies have reported similar differences from the target concentration 7 DAT, where measured concentrations are often approximately 50% of the target concentration (Osborne 1989; West and Parka 1981; West et al. 1983). Regression analysis indicated that there were no significant differences in the degradation of fluridone from 7-182 DAT for the SC and AS formulations (Figure 1A.).

An understanding of the initial and subsequent behavior of fluridone in treated waters will allow the development of efficient and effective herbicide treatments (Getsinger et al. 2002). With the introduction of new formulations to the aquatic market, it is important to understand if they will behave similar to the products that have already been used. Our data did not indicate any difference in the residual or degradation of fluridone in treated waters between the AS and SC formulations.

Hydrilla Efficacy Study

The efficacy of the two liquid formulations of fluridone was tested in mesocosms to determine biomass reduction of hydrilla after an 8 wk exposure to the herbicides. All concentrations of fluridone (5, 15, 25, 50, and 100 µg a.i. L^{-1}), regardless of formulation (AS and SC), caused a significant reduction in biomass when compared to untreated controls (Figure 1B). However, there were no differences in biomass reduction between the two formulations of fluridone at any concentration. The EC_{50} of fluridone was 6.3 (95% CI = 4.8-9.3) and 5.1 (3.3-11.4) µg a.i. L^{-1} for the AS and SC formulations respectively (Figure 1B).

Previous reports have shown that hydrilla is sensitive to fluridone at concentrations as low as 5 µg a.i. L^{-1} (Koschnick et al. 2003; MacDonald et al. 1993; Poovey et al. 2005). Our 56 d exposure results were similar to those of Poovey et al. (2005), who reported a GR_{50} (the concentration of fluridone required to reduce growth of hydrilla by 50%) of 5.78 µg a.i. L^{-1} based on a 90 d exposure to liquid fluridone. Koschnick et al. (2003) reported a 90% reduction in hydrilla biomass 92 d after exposure to a granular formulation of fluridone at a target concentration of 6 µg a.i. L^{-1}. The increased reduction of hydrilla biomass noted by Koshnick et al. (2003) was likely due to "bump" treatments applied 43 DAT to increase the concentration of fluridone back to 6 µg a.i. L^{-1} after initial degradation. These studies all suggest that hydrilla is highly susceptible to low concentrations of fluridone (5 µg a.i. L^{-1}) and that control can be achieved if this concentration is maintained over time. In summary, the AS and SC formulations of fluridone had very similar residue profiles in treated pond water and similar hydrilla efficacy in the study ponds and mesocosms.

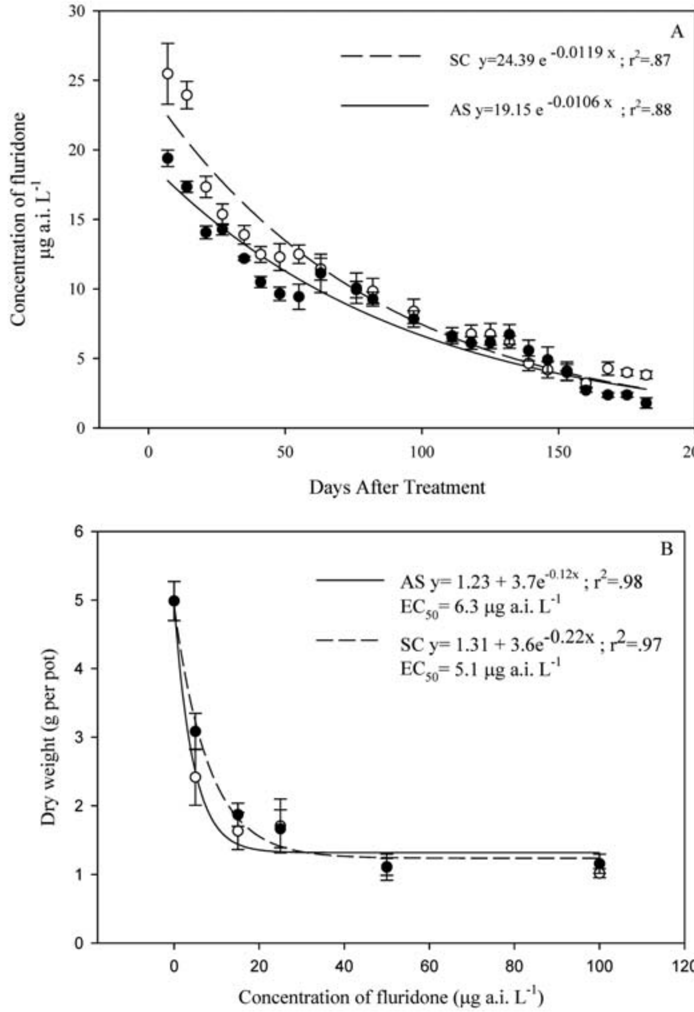

Figure 1A. Top. Average degradation curve of SC and AS formulations of fluridone in small ponds beginning 7 DAT. Open circles represent the mean ± standard error of the SC formulation and dark circles represent the mean ± standard error of the AS formulation. B. Bottom. Biomass of hydrilla treated with SC and AS formulations of fluridone at concentrations of 0, 5, 15, 25, 50 and 100 µg a.i. (active ingredient) L^{-1}. Open circles represent the mean ± standard error for the AS formulation and dark circles represent the mean ± standard error of the SC formulation. EC_{50} is the concentration of fluridone required to reduce hydrilla biomass by 50% over the 8 wk exposure period.

ACKNOWLEDGEMENTS

We appreciate the very able and timely water sampling by Tony Griffin of the South Florida Water Management District and water analysis by Envirologix Laboratories. These studies were funded in part by the Florida Department of Environmental Protection and the Aquatic Ecosystem Restoration Foundation.

LITERATURE CITED

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.

Getsinger, K. D., J. D. Madsen, T. J. Koschnick and M. D. Netherland. 2002. Whole lake fluridone treatments for selective control of Eurasian watermilfoil: I. Application strategy and herbicide residues. Lake Reserv. Manage. 18(3):181-190.

Getsinger, K. D., M. D. Netherland, C. E. Grue and T. J. Koschnick. 2008. Improvements in the use of aquatic herbicides and establishment of future research directions. J. Aquat. Plant Manage. 46:32-41.

Koschnick, T. J., W. T. Haller, V. V. Vandiver and U. Santra. 2003. Efficacy and residue comparisons between two slow-release formulations of fluridone. J. Aquat. Plant Manage. 41:25-27.

MacDonald, G. E., D. G. Shilling, R. L. Doong and W. T. Haller. 1993. Effects of fluridone on hydrilla growth and reproduction. J. Aquat. Plant Manage. 31:195-198.

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

Netherland, M. D. and K. D. Getsinger. 1995. Laboratory evaluation of threshold fluridone concentrations under static conditions for controlling hydrilla and Eurasian watermilfoil. J. Aquat. Plant Manage. 33:33-36.

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. Aquat. Plant Manage. 31:189-194.

Osborne, J. A., S. D. West, R. B. Cooper and D. C. Schmitz. 1989. Fluridone and N-methylformaide residue determination in ponds. J. Aquat. Plant Manage. 27:74-78.

Poovey, A. G. and K. D. Getsinger. 2005. Use of herbicides to control the spread of aquatic invasive plants. J. ASTM Int. Volume 2(10) 7pp.

Poovey, A. G., K. D. Getsinger and A. B. Stewart. 2005. Comparative response of two hydrilla strains of fluridone. J. Aquat. Plant Manage. 43:85-90.

West, S. D., R. O. Burger, G. M. Poole and D. H. Mowrey. 1983. Bioconcentration and field dissipation of the aquatic herbicide fluridone and its degradation products in aquatic environments. J. Agr. Food Chem. 31:579-585.

West, S. D. and S. J. Parka. 1981. Determination of the aquatic herbicide fluridone in water and hydrosoil: Effect of application method on dissipation. J. Agric. Food Chem. 29:223-226.