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Efficacy and Residue Comparisons between Two Slow-release Formulations of Fluridone[1]

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ABSTRACT

Residue profiles and efficacy of Avast and Sonar, two slow release pellet formulations of fluridone {1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenly]-4(1H)-pyridinone}, were compared in outdoor tanks. Hydrilla (*Hydrilla verticillata* (L.f.) Royle) and southern naiad (*Najas guadalupensis* (Sprengel) Magnus) were treated with a split application of 6, 12, 18 and 24 µg/l a.i. fluridone and the concentrations of both formulations compared over a 134-day period. Both pellet formulations exhibited very similar residues over time for each respective treatment, resulted in peak concentrations of fluridone 40 to 50 days after application, and effectively and similarly controlled southern naiad and hydrilla at all rates tested by 92 days after initial application.

Key words: controlled release, *Hydrilla verticillata*, *Najas guadalupensis*, Sonar®, and Avast®.

INTRODUCTION

Fluridone is a systemic herbicide that was registered by the US EPA in 1986 and is used exclusively in the United States for aquatic weed control. It is a pigment synthesis inhibitor (Bartels and Watson 1978) requiring a long sustained exposure (>60days) to control submersed plants (Haller et al. 1990, Fox et al. 1994). Due to its long exposure requirements, a slow release pellet formulation (SRP) has been commonly used in areas where the release of the active ingredient compensates for dilution from untreated water, such as in partial lake or flowing water applications. Controlled release delivery systems offer a way to maintain adequate contact time and exposure in a flowing water environment (Murphy and Barrett 1990).

Sonar SRP[3] is a clay-based formulation containing 5% active ingredient, and was reported to have a release rate of 10 to 16 days depending on the amount of agitation subjected to the pellets (Mossler et al. 1993). Similar results were observed in a static pond, with Sonar SRP reaching a peak concentration 15 days after treatment with a 139 day calculated half-life (Netherland et al. 1998). In slow moving water or water that was stirred gently, Sonar SRP released almost entirely in 10 days with 60% released in the first 3 days (Van and Steward 1986). Therefore, release rates of the slow release pellet appear to be influenced by the intensity of disturbance around the pellet, which may be partially caused by flowing water. Fluridone release rates from clay also vary depending on the type of clay carrier used in the formulation (Mossler et al. 1993). A specific formulation will release the active ingredient at a rate and over a period of time determined by the properties of the carrier (Murphy and Barrett 1990).

Currently, two slow release formulations of fluridone are commercially available, Sonar SRP and Avast SRP[4], the latter being a newly introduced clay-based formulation that appears similar to Sonar SRP, but there have been no studies comparing the formulations or efficacy of the two products. Therefore, a study was conducted to compare residues over time and determine efficacy on submersed plants of the two commercially available slow release formulations under static conditions.

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[3]Sonar SRP is a trademark of SePRO Corporation, Carmel, IN.

[4]Avast SRP is a trademark of Griffin LLC, Valdosta, GA.

MATERIALS AND METHODS

Thirty, 900-liter concrete tanks (dimensions of 218 cm by 76.8 cm by 51.4 cm deep) at the University of Florida's Fort Lauderdale Research and Education Center (FLREC) were cleaned and prepared for planting in the summer of 2000. Three-liter (dimensions of 15.25 cm diameters by 13 cm deep) plastic containers were filled with builder's sand amended throughout with 4g/kg of slow-release 15-9-12-osmocote fertilizer. Six apical sections (7 to 10 cm long) of hydrilla or southern naiad were planted in separate pots and into each concrete tank were placed twelve pots each of hydrilla and southern naiad. Pots were planted in September 2000, and pond water was allowed to flow through the tanks to promote optimal growth of the submersed plants.

Two formulations of fluridone SRP pellets, Avast and Sonar, were applied individually to the tanks on January 3, 2001 after plants reached the water surface and attained healthy growth. Theoretical applications of fluridone at 0, 6, 12, 18 and 24 µg/l (ppb) were applied to three random replicate tanks for each herbicide and each concentration for a total of 30 tanks. Water flow was ceased prior to application and pond water was only periodically added to the tanks to compensate for evaporation.

The weighed SRP pellets were carefully placed in single sand filled petri dish on top of a brick in the center of each treatment tank, 19.5 cm off the bottom of each tank. Sand was used to stabilize the petri dish and has little effect on fluridone release rate binding only 2 to 4% of the available fluridone (Mossler et al. 1993). Water for residue analysis was collected 19, 36, 68, 89, 110, 118 and 134 days after treatment and analyzed for fluridone content by the Avast-Test®, an enzyme linked immunosorbent assay developed by Griffin LLC. The single residue samples were randomly numbered and run blind by the analytical laboratory.

Split applications of fluridone pellets are commonly used to maintain desired contact and exposure times. Prior to the experiment, it was decided to re-apply or "bump" the treatment about 6 weeks after the first application. On February 15, 2001, 43 days after initial treatment, additional SRP was added to each tank to bring the theoretical fluridone values to 6, 12, 18 or 24 ppb as initially treated. For example, if on Day 36 an assigned 6 ppb treatment had 2 ppb fluridone in the water according to the water analysis, additional fluridone (4 ppb) would be added to bring the concentration to the 6 ppb theoretical value.

On April 26, 2001, 113 days after initial treatment and 70 days after re-treatment, the petri dishes containing SRP pellet remains were gently removed from the tanks, emptied into a plastic beaker and ground with sand and mixed aggressively to ascertain release of all remaining fluridone. Contents were poured back intro each respective tank and water samples were subsequently collected 5 and 22 days later.

One-half of the pots containing hydrilla or southern naiad (6) were harvested from each tank on April 5 (92 days after treatment) to determine initial impact on growth and the remaining pots harvested May 17 (134 days after treatment) to measure possible regrowth and recovery from initial injury. The plants were dried in an oven at 80 C and dry weights determined. Biomass and residue data were analyzed by multivariate repeated measured analysis using SAS statistical software, means for residues compared using Duncan's multiple range test (0.05 level of significance), and means for biomass compared using Dunnett's Test (0.05 level of significance).

RESULTS AND DISCUSSION

Fluridone residues were determined on approximate 3-week intervals during the study (Figure 1). Results from multivariate analysis indicate significant differences in fluridone content with respect to time ($p < 0.0001$) and for different target application concentrations ($p < 0.0001$). Therefore, the treatment effect on fluridone content was highly significant when averaged over the different times.

The residue data in Figure 1 indicates that about one-sixth of the target fluridone concentrations had been reached in the first 19 days after treatment, with the 6, 12, 18 and 24 ppb treatments showing approximately 1, 2, 3 and 4 ppb, respectively. Gradual increases in fluridone content of the treated water occurred through 36 days after initial treatment (DAT) with concentrations across all treatments ranging from 25 to 36% of target concentrations. Avast release rates ranged

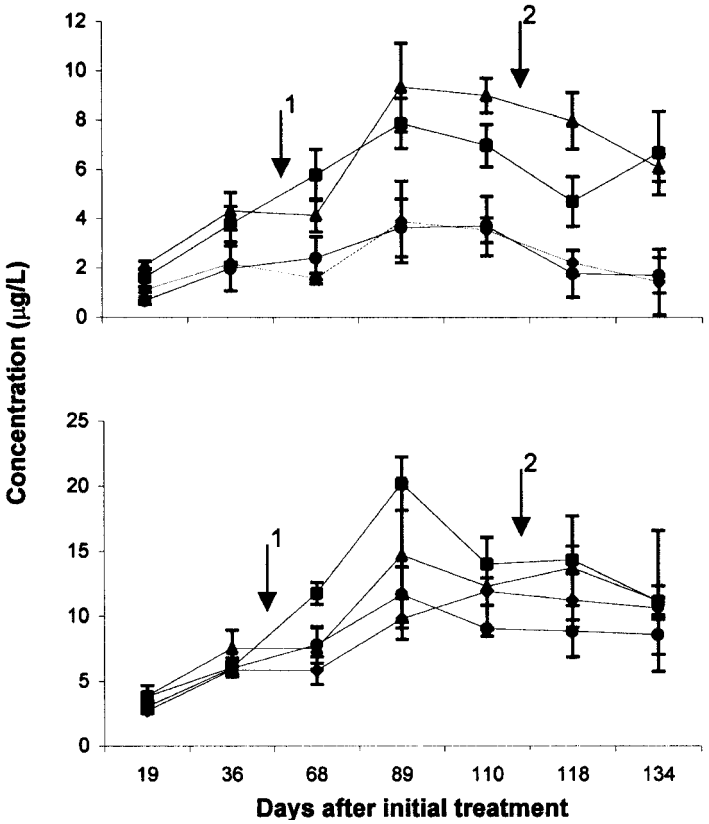

Figure 1. Fluridone residue profile from Avast and Sonar slow-release pellets over time in outdoor tanks at the FLREC. Initial treatment rates are indicated, with a second application 43 days after initial treatment to maintain theoretical concentrations at target doses (values are the means of three replications + standard deviation). Theoretical 6 and 12 ppb treatments (top) and 18 and 24 ppb (bottom - note different scales on y-axis). Arrows in graph denote when product was applied to maintain theoretical concentration (1) and when pellet remains were crushed to ascertain 100% release (2). ▲ = Avast 6 and 18 ppb, ● = Sonar 6 and 18 ppb, ◆ = Avast 12 and 24 ppb, ■ = Sonar 12 and 24 ppb.

from 33 to 36% of the theoretical concentration applied while Sonar ranged from 25 to 33%. Additional herbicide was added to increase concentrations towards the theoretical values 43 DAT.

Peak fluridone concentrations were measured 89 DAT, or 46 days after reapplication, and declined by 110 DAT for all treatments except Avast at 18 ppb and Sonar at 6 ppb. These two treatments reached peak concentrations on 110 DAT before declining. At peak values, the detected concentrations of fluridone ranged from 37 to 48% of the total applied. The maximum concentration never exceeded more than 50% of the total fluridone applied at any rate as the pellets released slowly over time and product degradation or plant uptake never allowed the fluridone content to reach theoretical treatment concentrations.

At day 113, the contents of the petri dishes with the pellet remains were poured into a plastic beaker and vigorously ground and stirred with a stick and distributed back into the experimental tanks. Residue data collected on Day 118, 5 days after grinding, showed slightly decreased fluridone content in the water from Day 110 suggesting that the active ingredient in the pellets had been almost entirely released by 113 DAT, or 70 days after retreatment. Fluridone residues in the water collected at final harvest on day 134 showed no differences in concentrations between the commercial products at any treatment rate, and exhibited a slight decrease from Day 118. The percentage of herbicide remaining compared to the total applied for both applications was similar for Sonar and Avast across all treatment levels: 6 ppb; 17% and 15%, 12 ppb; 38% and 31%, 18 ppb; 35% and 29%, and 24 ppb; 28% and 27%, respectively.

Residues between the two SRP formulations were similar over the seven different sampling times with few exceptions (according to Duncan's multiple range test at $p < 0.05$). The 6 ppb treatment for both products was very similar reaching nearly 4 ppb 89 to 110 DAT, with differences observed only at the 19 day sample. Fluridone concentrations between the two products at 12 and 18 ppb appeared to be similar with exceptions only at 68 and 110 days after treatment. Differences in concentrations for the 24 ppb treatments were observed 36 and 68 DAT, but were equivalent for the rest of the sampling times. Under static conditions, Avast and Sonar have release, uptake and degradation rates that result in similar fluridone concentrations over time.

Data from the 92 day harvest of southern naiad and hydrilla is presented in Figure 2; harvest data from 134 DAT were similar and therefore are not presented. Results from multivariate analysis of both 92 day and 134 day harvests showed a significant effect due to time ($p = 0.0031$) and there was a significant time and treatment interaction ($p < 0.0001$). All treatment rates of Avast and Sonar from 6 to 24 ppb provided over 90% reduction in southern naiad compared to untreated control plants at the 92 day harvest. Southern naiad plants remaining in the treated tanks had few if any leaves and poorly developed root systems, probably unable to survive much longer. Hydrilla was damaged to an even greater degree as few pots had any hydrilla remaining. Both commercial products provided equivalent control of both southern naiad and hydrilla. Data from the 134-day harvest resulted in greater than 95% biomass reduction across

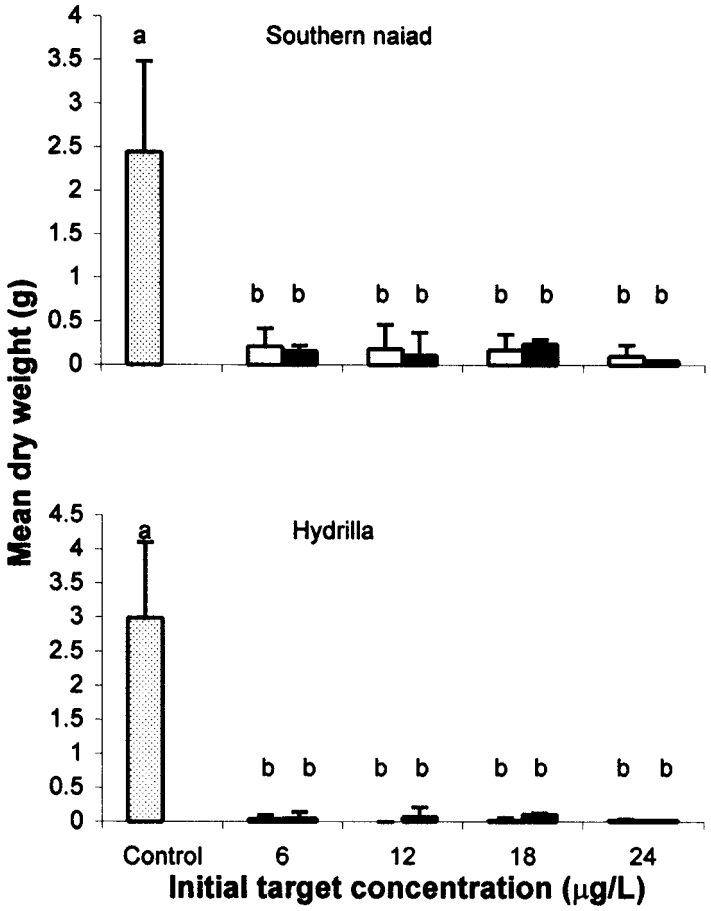

Figure 2. Mean dry weight per container of southern naiad (top) and hydrilla (bottom) biomass harvested 92 days after initial treatment with Avast and Sonar slow-release pellets. Values followed by different letters are significantly different at 0.05 level according to Dunnett's test (n = 18). □ = Avast ■ = Sonar

all rates for both species with no apparent recovery. Thus, the residues of fluridone in the water resulting from applications of Avast and Sonar SRP pellets were not only the same, but plant control by the two products was also similar.

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