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Carfentrazone-ethyl for Control of Giant Salvinia

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INTRODUCTION

Giant salvinia (*Salvinia molesta* D.S. Mitchell) is an invasive aquatic fern that has been reported in at least 12 U.S. states, including Hawaii, Louisiana, South Carolina, and Texas, and has the potential to become a serious problem in public water bodies (Owens et al. 2005). Due to its explosive growth rate, giant salvinia can form dense mats up to 1 m thick across the water surface (Oliver 1993). These mats can severely reduce dissolved oxygen, shade out submersed plants, clog waterways, and interfere with fishing, swimming, boating, and irrigation. Due to the detrimental impacts that giant salvinia can have on an area, water resource managers are looking for effective strategies to control this noxious weed.

Herbicides play an important role in the management of giant salvinia and there are currently four active ingredients: chelated copper, diquat (6,7-dihydrodipyrido[1,2-α:2',1'-c]pyrazinediium), fluridone (1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4(1H)-pyridinone), and glyphosate (N-(phosphonomethyl)glycine) that have shown efficacy against this invasive fern. Of these four, diquat and glyphosate are the most effective (Nelson et al. 2001, Fairchild et al. 2002, McFarland et al. 2004). With documented glyphosate and diquat resistant plants appearing in terrestrial systems (Powles et al. 1998, Tucker and Powles 1991) and evidence of herbicide resistance beginning to be reported in some aquatic weeds (Michel et al. 2004, Arias et al. 2005, Koschnick 2005, Netherland et al. 2005), it is critical to not overuse products when managing giant salvinia and other weeds. Therefore, it is important to investigate and develop new herbicides with different modes of action that can be added to the suite of tools used to manage invasive aquatic plants.

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Carfentrazone-ethyl (ethyl α,2-dichloro-5-[4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl]-4-fluorobenzenepropanoate), hereafter referred to as carfentrazone, is a quick-acting protoporphyrinogen oxidase inhibitor that received approval as a reduced risk pesticide for use in aquatic sites from the U.S. Environmental Protection Agency (USEPA) in 2004. Marketed by the trade name, Stingray® (FMC Corporation, Philadelphia, PA), carfentrazone is not cross resistant with other classes of herbicides and recommended aquatic application rates are low (≤0.22 kg/ha). Koschnick et al. (2004) showed that carfentrazone can effectively control the closely related species, salvinia (*Salvinia minima* Baker), and other floating plants such as water hyacinth (*Eichhornia crassipes* (Mart.) Solms-Laub), and water lettuce (*Pistia stratiotes* L.). The objective of this study was to determine the efficacy of the herbicide, carfentrazone, against the floating invasive fern, giant salvinia.

MATERIALS AND METHODS

Giant salvinia was cultured in large outdoor tanks at the U.S. Army Engineer Research and Development Center's Lewisville Aquatic Ecosystem Research Facility near Dallas, TX. Culture media consisted of filtered Lake Lewisville water amended with Stearns Miracle-Gro lawn fertilizer (36-6-6) at a rate that provided 10 mg N L^{-1}.

One week prior to treatment, healthy culture plants were transferred to 76-L plastic experimental containers, filled with nutrient-amended lake water, and placed outdoors in 1600-L water baths for temperature control. Enough plant material was added to each container to cover approximately 75% of the water surface. One week of growth acclimation was allowed in this system so that plants could vegetatively expand and cover 100% of the water surface in each experimental container. Following the acclimation period, carfentrazone was applied as a foliar spray at the following treatment rates: 0, 0.028, 0.056, 0.112, 0.168, and 0.224 kg ai ha^{-1}. Sun-Wet, a methylated seed oil surfactant, was added to the spray mixture at a rate of 0.25% v:v per recommendations from FMC field development personnel. Treatments were applied using a CO_2-pressurized sprayer (R&D Sprayers, Opelousas, LA) equipped with a hand-held, single-nozzle (TeeJet® solid cone spray tip) spray header calibrated to deliver a spray volume of 935 L ha^{-1} (100 gal A^{-1}). Shielding was placed around each experimental unit during the application process to prevent herbicide drift and cross contamination of spray material between treatments.

Visual ratings of percent control were recorded at 2, 4, 7, 14, 21, and 28 days after treatment (DAT). Salvinia control was assessed on a scale of 0 to 100 where 0 = no control; and 100 = complete plant mortality. Observations of plant discoloration, wilting, plant deformity, and re-growth were also noted throughout the study. Salvinia biomass (all floating, viable plant material) was harvested at 28 DAT and dried at 70°C to a constant weight.

Treatments were randomly assigned and replicated three times. Final plant biomass was analyzed using the Holm-Sidak method and percent control ratings were analyzed using the Tukey method at the 0.05 level of significance.

RESULTS AND DISCUSSION

At 2 DAT, between 85 and 95% of all carfentrazone-treated plants were necrotic with a small amount of viable bud and rhizome tissue still present under the surface mat. By 14 DAT, proliferation of viable tissue was greatest in containers treated with rates of 0.028 and 0.056 kg ai ha^{-1}, where percent control dropped from 98.7% (for both rates) 7 DAT to 83.3 and 81.7% respectively 28 DAT (Table 1). Regrowth of tissue not initially killed is a common response to contact herbicide treatments due to limited translocation throughout plant tissues (Lembi and Ross 1985). Regrowth of giant salvinia has also been reported following treatment with other contact herbicides (Glomski et al. 2003; Nelson et al. 2001).

Percent control of giant salvinia treated at 0.112, 0.168, and 0.224 kg ai ha^{-1} was >97% 28 DAT (Table 1). Final biomass showed a difference between lower rates (0.028 and 0.056) and middle to higher rates (0.112, 0.168, 0.224), and all treatments were significantly different than the untreated control (Figure 1). These results suggest that carfentrazone could be used as an alternative to, or in rotation with, glyphosate and diquat to prevent the overuse of, and potential resistance to, these products. Carfentrazone, like diquat, provides quicker burn-down and tissue destruction (days) than slower-acting products such as fluridone and glyphosate (weeks), and could have a management role when rapid removal of giant salvinia biomass is required. Furthermore, because of its USEPA reduced-risk status, carfentrazone would be a good candidate for aquatic sites where water use restrictions (drinking, lfishing, swimming, irrigation) may be an issue.

TABLE 1. PERCENT CONTROL RATINGS (± SE) OF GIANT SALVINIA FOLLOWING TREATMENT WITH CARFENTRAZONE.

Carfentrazone (kg ai ha^{-1})	Days after treatment (percent control)[1]					
	2	4	7	14	21	28
Control	0.0 ± 0.0 a	0.0 ± 0.0 a	0.0 ± 0.0 a	0.0 ± 0.0 a	0.0 ± 0.0 a	0.0 ± 0.0 a
0.028	85.0 ± 2.9 b	96.0 ± 1.0 b	98.7 ± 0.3 b	96.0 ± 1.0 b	91.7 ± 1.7 b	83.3 ± 3.3 b
0.056	88.3 ± 1.7 b	98.0 ± 0.0 b	98.7 ± 0.3 b	91.7 ± 1.7 bc	86.7 ± 1. 7bc	81.7 ± 1.7 b
0.112	88.3 ± 1.7 b	98.0 ± 0.0 b	99.0 ± 0.0 b	97.0 ± 1.0 c	97.3 ± 1.2 c	97.7 ± 1.3 c
0.168	88.3 ± 4.4 b	97.0 ± 1.0 b	98.7 ± 0.3 b	98.3 ± 0.3 c	97.3 ± 1.2 c	97.7 ± 1.3 c
0.224	90.0 ± 0.0 b	98.0 ± 0.0 b	99.0 ± 0.0 b	97.3 ± 1.2 c	97.3 ± 1.2 c	98.7 ± 0.3 c

[1]Percent control is a visual assessment of plant mortality and is expressed on a scale of 0 to 100% where 0% equals no control and 100% equals complete control. Means in a column followed by the same letter do not significantly differ (α = 0.05, Tukey).

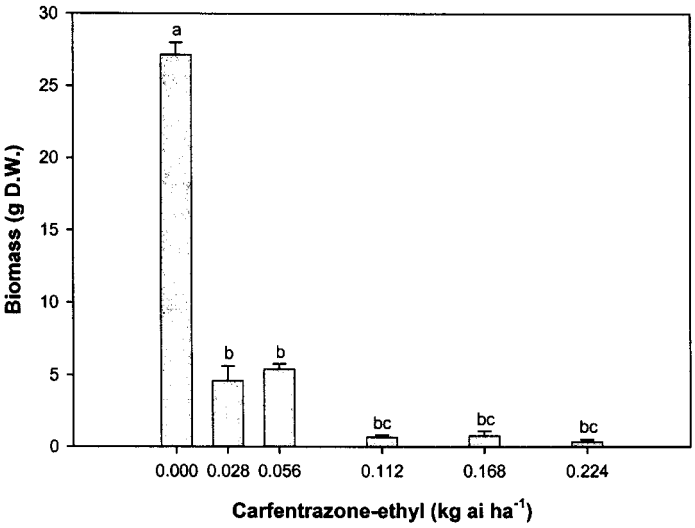

Figure 1. Mean (± SE) dry weight biomass of giant salvinia biomass 28 days after treatment with carfentrazone-ethyl. Bars sharing the same letter do not significantly differ from each other.

In conclusion, carfentrazone, at rates of 0.112, 0.168 to 0.224 kg ai ha^{-1}, is effective at controlling giant salvinia; however retreatment may be necessary to control any remaining viable plant tissue eading to regrowth of treated plants. While results of small-scale trials show promise, evaluation of carfentrazone efficacy against giant salvinia in a variety of field settings must be assessed to develop operational guidance for that use.

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