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.

Carfentrazone-ethyl for Control of Giant Salvinia

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LITERATURE CITED

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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-fluorobenzepropanoate), 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. Shielding was placed around its USEPA reduced-risk status, carfentrazone would be a good alternative to, or in rotation with, glyphosate 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, fishing, swimming, irrigation) may be an issue.

**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, fishing, swimming, irrigation) may be an issue.

**Table 1. Percent Control Ratings (± SE) of Giant Salvinia Following Treatment with Carfentrazone.**

<table>
<thead>
<tr>
<th>Carfentrazone (kg ai ha⁻¹)</th>
<th>2</th>
<th>4</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.0 ± 0.0 a</td>
<td>0.0 ± 0.0 a</td>
<td>0.0 ± 0.0 a</td>
<td>0.0 ± 0.0 a</td>
<td>0.0 ± 0.0 a</td>
<td>0.0 ± 0.0 a</td>
</tr>
<tr>
<td>0.028</td>
<td>85.0 ± 2.9 b</td>
<td>96.0 ± 1.0 b</td>
<td>98.7 ± 0.3 b</td>
<td>96.0 ± 1.0 b</td>
<td>91.7 ± 1.7 b</td>
<td>83.3 ± 3.3 b</td>
</tr>
<tr>
<td>0.056</td>
<td>88.3 ± 1.7 b</td>
<td>98.0 ± 0.0 b</td>
<td>98.7 ± 0.3 b</td>
<td>91.7 ± 1.7 bc</td>
<td>86.7 ± 1.7 bc</td>
<td>81.7 ± 1.7 b</td>
</tr>
<tr>
<td>0.112</td>
<td>88.3 ± 1.7 b</td>
<td>98.0 ± 0.0 b</td>
<td>99.0 ± 0.0 b</td>
<td>97.0 ± 1.0 c</td>
<td>97.3 ± 1.2 c</td>
<td>97.7 ± 1.3 c</td>
</tr>
<tr>
<td>0.168</td>
<td>88.3 ± 4.4 b</td>
<td>97.0 ± 1.0 b</td>
<td>98.7 ± 0.3 b</td>
<td>98.3 ± 0.3 c</td>
<td>97.3 ± 1.2 c</td>
<td>97.7 ± 1.3 c</td>
</tr>
<tr>
<td>0.224</td>
<td>90.0 ± 0.0 b</td>
<td>98.0 ± 0.0 b</td>
<td>99.0 ± 0.0 b</td>
<td>97.3 ± 1.2 c</td>
<td>97.3 ± 1.2 c</td>
<td>98.7 ± 0.3 c</td>
</tr>
</tbody>
</table>

¹Percent 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).
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 leading 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.

**ACKNOWLEDGMENTS**

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**LITERATURE CITED**


