

Clearigate® Treatments for Control of Giant Salvinia

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INTRODUCTION

Giant salvinia (*Salvinia molesta* D.S. Mitchell) is an invasive aquatic fern native to Brazil (Thomas and Room 1986). It was first discovered in the U.S. in 1995 (Johnson 1995), and was most likely introduced through the aquarium and water garden industry. Giant salvinia has been described as having an “explosive” growth rate and can form dense mats up to 1 m thick across the water surface (Holm et al. 1977, Oliver 1993). Dense mats of giant salvinia can severely reduce the oxygen supply to the water column by limiting gas exchange between the atmosphere and the water. Dissolved oxygen production from photosynthesis is also limited due to minimal light penetration to phytoplankton and submersed aquatic plants. Decreased oxygen levels can be stressful and even detrimental to fish and other aquatic organisms (Holm et al. 1977, Oliver 1993). In addition, the density and diversity of native submersed plants can be reduced as a result of shading by giant salvinia mats (Oliver 1993).

Not only can giant salvinia negatively affect aquatic organisms, it can also severely impact human use of waterways. Giant salvinia hinders transportation and recreation by clogging waterways, and interferes with irrigation by slowing the water current and increasing sedimentation in irrigation canals (Sculthorpe 1967, Thomas and Room 1986). Giant salvinia provides habitat for mosquitoes, which are vectors for diseases such as dengue fever, elephantiasis, encephalitis and malaria (Oliver 1993). With recent concerns in the U.S. about West Nile virus (Campbell et al. 2002), researchers speculate that giant salvinia may also harbor the mosquitoes that spread this disease. Due to the detrimental effects giant salvinia can have on humans and the aquatic environment, it is important to prevent and control the spread of this plant. An effective way to control giant salvinia is through the use of herbicides. Small-scale outdoor studies have shown that herbicides such as diquat (6,7-dihydrodipyrido (1,2-a:2',1'-c) pyrazinediium dibromide), glyphosate (N-(phosphonomethyl) glycine), and copper (copper chelate) are effective against this plant (Nelson et al. 2001, Fairchild et al. 2002).

Results of recent field trials using the chelated copper formulation Clearigate®⁴ showed that applying a 20% solution by volume was effective for controlling populations of giant salvinia in irrigation canals.⁵ Lower rates may be efficacious, thereby reducing chemical use and cost; however, little is known about the dose-response effects of Clearigate® against giant salvinia. The objective of this study was to determine the effective rate range of chelated copper applied as Clearigate® for control of giant salvinia.

MATERIALS AND METHODS

Giant salvinia was collected from established populations at a local field site and cultured in large outdoor tanks at the Lewisville Aquatic Ecosystem Research Facility (LAERF), located in Lewisville, TX (33°N latitude, 97°W longitude). Plants were cultured in water amended with Miracle-Gro® lawn fertilizer (36% N; 6% P; 6% K; 0.325% Fe) (Scotts, Marysville, OH) at a rate that provided 10 mg N L⁻¹ in the water column.

One week prior to herbicide treatment, an equal amount of fresh plant material (enough to cover 75% of the water surface) was transferred to 76-L (20-gal) plastic containers (approximately 50 cm diameter by 58 cm height) filled with nutrient-amended water and placed outdoors in direct sunlight. The same nutrient additions used in the culture tanks were utilized here. In addition to nutrients, the inert dye, Aquashade® (Applied Biochemists, Milwaukee, WI) was added to the culture media at a rate of 1 mg L⁻¹ to prevent algal growth. Controlling algae was necessary to prevent potential nutrient depletion and/or variation in nutrient concentration among experimental tanks. A 1-week pretreatment growth period was needed for giant salvinia to acclimate following the transfer from culture tanks to experimental tanks, and for plants to vegetatively expand and produce a single thick layer that covered 100% of the water surface of each experimental tank.

Clearigate® was applied on August 11, 2000 as a foliar spray at the following treatment rates: 0, 0.5, 1, 2, 5, 10, 15, and 20% solution by volume. Treatments were applied using a CO₂-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 vol-

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⁴Clearigate® is a registered trademark of Applied Biochemists, Milwaukee, WI.

⁵Wescott, P. Aquatic vegetation control in irrigation conveyance systems and treatment results on *Salvinia molesta* with Clearigate aquatic herbicide. Aquatic Plant Management Society 40th Annual Meeting, July 16-20, 2000, San Diego, CA. p. 21.

TABLE 1. PERCENT CONTROL OF GIANT SALVINIA AFTER TREATMENT WITH CLEARIGATE®.

Clearigate® (%) ²	Days after treatment (percent control) ¹						
	1	3	7	14	21	28	42
0	0 c	0 e	0 d	0 e	0 d	0 c	0 d
0.5	0 c	0 e	0 d	0 e	0 d	2 c	7 d
1	0 c	12 d	2 d	6 e	2 d	3 c	0 d
2	1 c	25 c	7 d	20 d	13 cd	10 c	15 cd
5	68 b	73 b	33 c	38 c	27 c	17 c	30 c
10	83 a	78 ab	80 b	58 b	53 b	43 b	57 b
15	85 a	87 a	83 ab	75 a	70 ab	53 ab	73 a
20	92 a	88 a	88 a	85 a	82 a	75 a	73 a

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 ($\alpha = 0.05$, Waller-Duncan *k*-ratio *t* test).

²Rate is based on a percent solution mixed v:v and delivered in a total spray volume of 1,870 L ha⁻¹ (200 gal A⁻¹).

ume of 1,870 L ha⁻¹ (200 gal A⁻¹). Each tank was shielded during the application of herbicide to prevent cross contamination of spray material between treatments.

Visual ratings of percent giant salvinia control were recorded 1, 3, 7, 14, 21, 28, and 42 days after treatment (DAT). Giant salvinia control was assessed on a scale of 0 to 100 where 0 = no control; and 100 = complete plant mortality. Observations of plant stunting, discoloration, wilting, plant deformity, and re-growth were also noted at each evaluation period. These observations were not assigned numerical ratings or statistically analyzed however, they were used to describe overall treatment performance. All living plant material of giant salvinia was harvested at the conclusion of the study (42 DAT) and dried at 70 C to a constant weight.

Treatments were randomly assigned and replicated three times. Visual ratings of percent control were analyzed using the Waller-Duncan *k*-ratio *t* test at the 0.05 level of significance. Final plant biomass data were subjected to regression analysis.

RESULTS AND DISCUSSION

Visual ratings of percent control showed that low rates of Clearigate® at 0.5, 1, and 2% were not effective against giant salvinia (Table 1). Compared to untreated plants, Clearigate® at 5 and 10% provided significant plant control throughout the study, however percent control readings decreased over time. A similar trend was seen with Clearigate® treatments of 15 and 20%, where initial control was 85% and 92%, respectively, then gradually decreased to 73% by the end of the study period. This decrease in percent control was due to re-growth of plant tissues not initially killed, and is a common response following treatment with contact herbicides, which have limited translocation throughout plant tissues (Lembi and Ross 1985). Re-growth of giant salvinia was also reported by Nelson et al. (2001) when plants were treated with the copper formulation Komeen® (derived from copper-ethylenediamine complex and copper sulfate pentahydrate).

Visual observations of the plants showed that symptoms were present 1 DAT for all Clearigate® treatments and persisted throughout the study. Symptoms ranged from slight brown-

ing and yellowing at low rates of 0.5 and 1%, to severe necrosis and sinking of plant tissue at rates of 5 to 20%. Chlorotic new growth was observed 3 DAT for the 1 and 2% treatments, 7 DAT for the 5% treatment, and 14 DAT for the 10, 15, and 20% treatments. Enough new growth occurred at 0.5% that biomass was similar to untreated controls by 42 DAT.

The effect of Clearigate® on giant salvinia biomass 42 DAT is shown in Figure 1 and can be described as an exponential curve. Biomass was reduced by 10 to 88% for the 0.5 to 20% treatments. In many of the treatments, there was enough living biomass remaining to re-infest a treated area.

Although the objective of the study was to determine if low rates of Clearigate® were efficacious, it is clear from the data that higher rates of 15 and 20% were the most effective at controlling giant salvinia, reducing biomass by 84 and 88% respectively. Nelson et al. (2001) however, reported that a low rate of 2.5% Komeen® reduced biomass by 92%. Differences in activity between the copper products may be attributed to differences in formulation; Komeen® contains 8% active ingredient whereas Clearigate® contains only 3.8%. The gradual decrease in percent control readings over time in the present

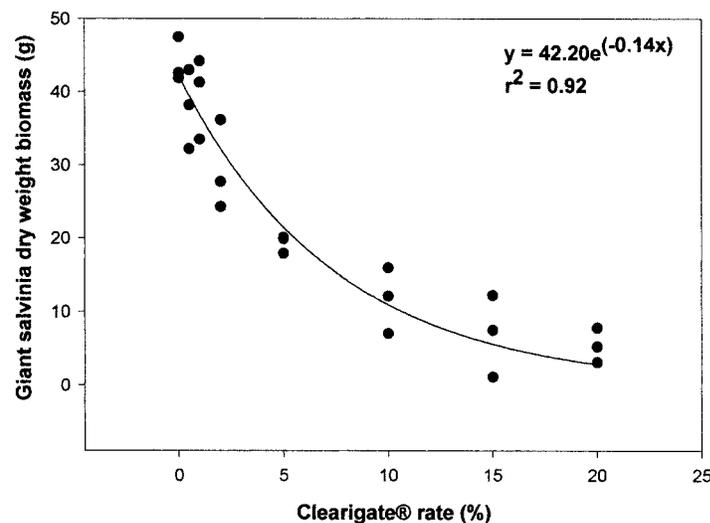


Figure 1. Dry weight biomass of giant salvinia 42 days after treatment with Clearigate® applied as a percent solution.

¹Komeen® is a registered trademark of Griffin L.L.C., Valdosta, GA.

study indicates that follow-up treatments may be necessary to prevent giant salvinia from re-colonizing a treated area. Although high rates of Clearigate® followed by reapplication to control surviving plants may be discouraging, there are some situations when using Clearigate® may be advantageous. As demonstrated by Nelson et al. (2001) and Fairchild et al. (2002), diquat and glyphosate are very effective at controlling giant salvinia, but both herbicides are inactivated by soil particles. In situations where the plant frond surfaces are covered with mud deposits or are soiled from turbid waters, Clearigate®, which is not inactivated by soil particles, would be a more effective herbicide. Also, there are no water use restrictions when applying Clearigate® to irrigation canals and it can be applied near potable water intakes. Although they provide excellent control, diquat-treated water cannot be used to irrigate crops for 5 DAT and glyphosate cannot be applied to water within 0.8 km (0.5 mile) of potable water intakes. Clearigate® at rates of 15 and 20% provide natural resource managers another option for controlling giant salvinia.

ACKNOWLEDGMENTS

The authors would like to thank the Aquatic Ecosystem Restoration Foundation for sponsoring this project, and Ap-

plied Biochemists, Inc., for providing the herbicide products. Permission was granted by the Chief of Engineers to publish on this information. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

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