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Regeneration of Giant Salvinia from Apical and Axillary Buds following Desiccation or Physical Damage

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INTRODUCTION

Giant salvinia (*Salvinia molesta* Mitchell) is a floating aquatic fern native to southeastern Brazil and currently found in tropical to temperate regions around the world. This species has been reported in more than 20 countries, usually introduced as an aquarium or water garden ornamental (Room et al. 1981). Dense mats of giant salvinia can impede water-based transportation, irrigation, hydroelectric production, and flood and mosquito control. These mats can also destroy fish and wildlife habitats, degrade water quality, and hinder endeavors such as rice cultivation and fishing (Holm et al. 1977, Mitchell 1979). An aggressive aquatic species, giant salvinia can completely cover water surfaces and has been shown to form mats up to 1 m thick (Thomas and Room 1986).

Each ramet of giant salvinia possesses a horizontal rhizome comprised of an internode, a node, two floating leaves, a third modified leaf that acts as a root, an apical bud and axillary buds (Bonnet 1955, Room 1983). Due to occasional branching, several ramets may appear along a rhizome. Also, as individual leaf pairs contain at least a pair of axillary buds collectively, these structures can be considered a ramet as well.

Because giant salvinia does not reproduce sexually (Oliver 1993), its survival during periods of stress depends on protection of meristematic tissues in buds on the rhizome. The rhizomes of the species fragment easily and new plants arise from apical and axillary buds (Harley and Mitchell 1981). In uncrowded populations, buds are generally found a few centimeters underwater. However in dense mats, some buds are exposed to air (Whiteman and Room 1991). Thick mats can provide protection to buds even when frost or freezing air temperatures kill the floating leaves. Sufficient portions of the buds are protected to regenerate the population when more favorable environmental conditions prevail (Harley and Mitchell 1981, Whiteman and Room 1991).

Under nitrogen-rich, uncrowded conditions, vegetative fragmentation can occur. As each bud develops, older rhizomes develop abscission layers resulting in fragmentation and widespread dispersal of protected buds (Harley and Mitchell 1981, Jacono and Pitman 2001). Giant salvinia buds can also be dispersed when mats of the plant are disturbed by human activities, wave action, wind, animal movement or flooding (Oliver 1993, Smart et al. 1999).

Because the apical buds are protected to ensure better survival of giant salvinia, this study focused on the effects of 1) drying of buds, and 2) new growth based on bud size.

METHODS

This study was conducted at the Lewisville Aquatic Ecosystem Research Facility (LAERF) in Lewisville, TX. All experiments were conducted using small plastic ice-cube trays with 14 slot filled with DI (deionized) water. Trays were maintained at room temperature under fluorescent lights set with a timer to provide a 14:10 light: dark photoperiod. Giant salvinia was obtained from outdoor research ponds maintained at the LAERF. Located in the USDA hardiness zone 7b, the LAERF (latitude 33°04’45”N, longitude 96°57’30”W) is one of the more northern locations at which the giant salvinia is known to overwinter in the United States (Owens et al. 2004).

Experiment 1. Effects of Desiccation

Duplicate pairs of mature, erect giant salvinia leaves with a protected apical bud were excised from ramets, and placed onto a wire drying rack at ambient room temperature and held different intervals of 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3, 3.5, 4, and 6 hours. At the end of each desiccation period, one of the paired plants was weighed, dried, and reweighed to determine moisture content while the other was assayed to determine viability. Viability was determined by placing the dried leaf pair into a DI water filled and numbered slot in the tray. After 30 days, viability as determined by visible new growth of each bud was noted and recorded. Ten replicate buds were excised per drying time. An ANOVA was performed with a Tukey’s being used to determine statistical differences among the means.

Experiment 2. Effects of Bud Size

Fifty apical and axillary buds were excised, measured for length (cm) and width (cm), and placed separately into the DI water filled slots for observation of new growth for 30 days. Five size classes of the buds were established based on 0.1 cm increments in length, ranging from a minimum length of 0.2 cm to a maximum of 0.6 cm (Table 1). A regression was employed comparing viability (%) with moisture content (%).

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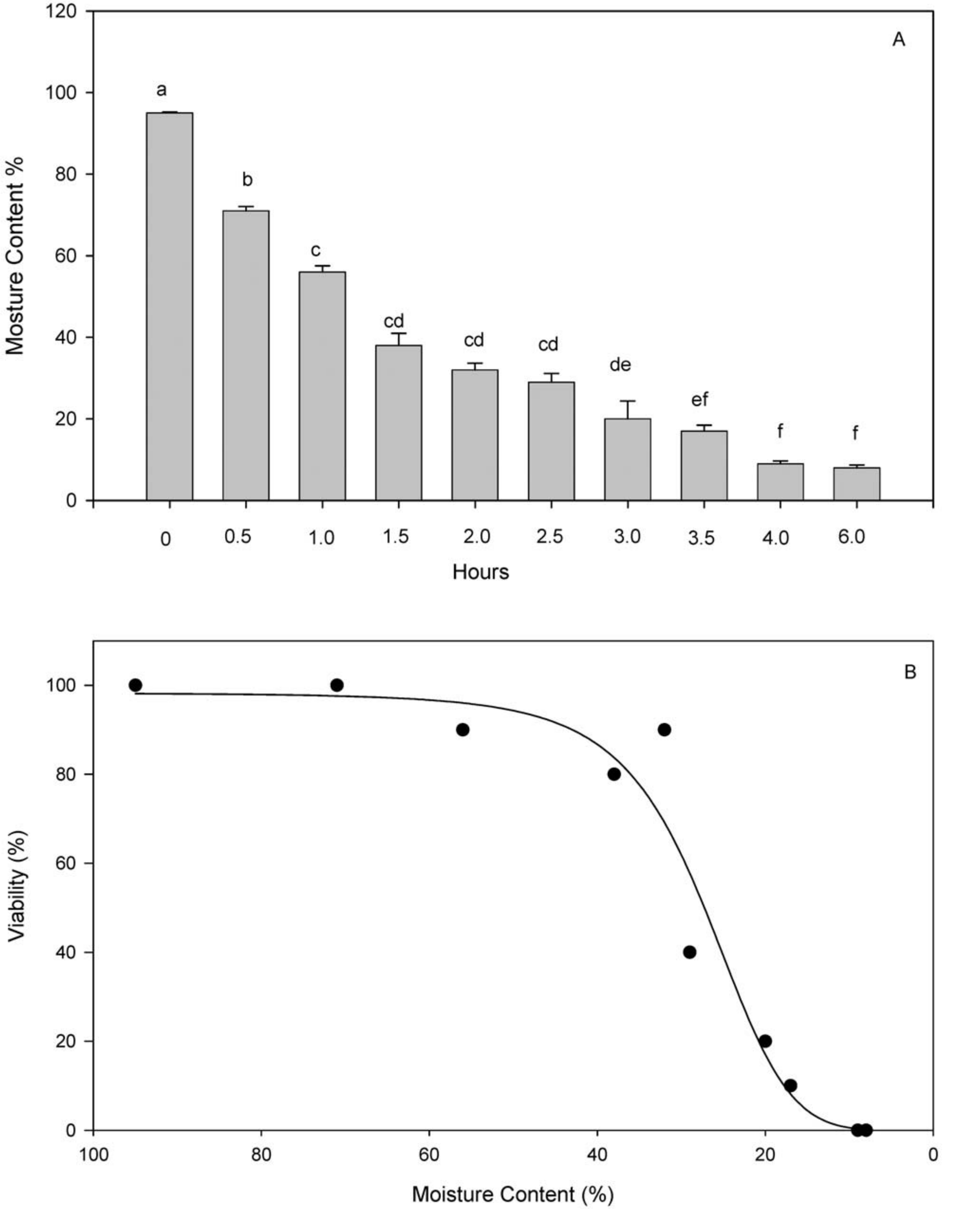

Figure 1. (A) Percent moisture content for giant salvinia dried for different periods of time, and (B) Percent viability by percent moisture content for giant salvinia.

TABLE 1. EXCISED BUD LENGTH AND WIDTH (CM), N (NUMBER OF REPLICATES), AND APICAL AND LATERAL BUD VIABILITY PERCENTAGES FOR EXPERIMENT 2.

Excised bud length (cm)	Width (cm)	N	Apical buds (%)	Lateral buds (%)
0.2	0.1	10	0	0
0.3	0.15-0.2	10	67	67
0.4	0.015-0.03	10	100	100
0.5	0.02-0.03	10	100	100
0.6	0.02-0.03	10	100	100

RESULTS AND DISCUSSION

Moisture content of exposed, excised salvinia steadily decreased over the desiccation period (Figure 1). Significant differences in moisture content were observed between the undesiccated control and all treatments; however, effects on viability were not observed until the salvinia buds had dried for 2.5 hours. At 2 hours drying, new growth was still observed for greater than 80% of the buds by the 2.5 hour drying, new growth was reduced to approximately 40% even though moisture content was only 1% less than the giant salvinia buds that were dried for 2.0 hour. No new growth was exhibited at 4 or 6 hours drying. It appears that moisture content of less than 30% affects viability of giant salvinia buds (Figure 1 A, B).

Giant salvinia buds (apical and lateral) that measured 0.2 cm or less did not produce new growth during the 30-day experimental time period. Sixty-seven percent of giant salvinia buds that measured 0.3 cm in length produced new growth and all buds that measured 0.4 cm and greater produced new growth in 30 days (Table 1). Most buds in fact produced the new growth within 2 weeks after the buds were placed into DI water. There were no significant differences found between apical and lateral buds. Although not measured, perhaps nutrients and carbohydrates were not sufficient to provide new growth in buds measuring less than 0.2 cm.

Can a new giant salvinia infestation occur even if most of the mat is destroyed except for the protected buds? From this study, we are able to conclude that buds can produce new growth under certain stressful conditions. They must be greater than 0.2 cm in length and they must possess greater than 30% moisture content to survive. It is likely that buds must also contain sufficient stored nutrients and carbohydrates to produce new growth, but analysis of these requirements awaits further study.

Herbicide treatments on Lake Conroe, TX for control of giant salvinia found that even though good spray coverage was achieved with the contact herbicide diquat, after approximately 2 weeks post-treatment, juvenile giant salvinia was observed, suggesting regrowth via the protected buds. Usage of a systemic herbicide containing the active ingredient glyphosate enabled better control of giant salvinia on Lake Conroe due to the internal translocation of the herbicide to the protected buds (B. Kellum, pers. comm.).[4]

Additionally, Owens et al. 2004 found that protection of the giant salvinia buds, during freeze events at the LAERF enabled the giant salvinia to overwinter and resume growth in the ponds as air temperatures warmed. Buds are, after all, the vegetative means for giant salvinia to disperse throughout invaded aquatic systems.

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