Growth of *Sagittaria subulata* and Interaction with Hydrilla[1]

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ABSTRACT

Dry weight of the diminutive submersed arrowhead [*Sagittaria subulata* (L.) Buch.] cultured for 32 weeks in pans filled with sand amended with fertilizers and held in an outdoor tank with flowing pond water was 8.7 times higher than plants grown in sand alone. However, the dry weight of plants in the highest level of fertilizer was estimated to be 89% less than plants collected from a field population in the Wakulla River, Florida. When arrowhead plants were grown for 31 weeks, after which sprouted hydrilla [*Hydrilla verticillata* (L.f.) Royle] tubers were planted and grown for 8 weeks, shoot dry weight was 44% lower for hydrilla planted in the established stand of arrowhead as compared to hydrilla planted alone. Furthermore, root dry weight of the hydrilla plants was the same regardless of the planting condition. The number of tubers produced by the hydrilla planted in the arrowhead was 59% lower than for hydrilla planted alone. Weight of the arrowhead plants was not influenced by planting the sprouted hydrilla tubers. These data indicate this arrowhead plant will resist the initial colonization by hydrilla.

Key words: Biomass, competition, native aquatic plants, propagules, submersed arrowhead plants, tubers.

INTRODUCTION

An aquatic plant interacts with members of its own species as well as individuals of other species as it colonizes and grows in an area, and competes for water, nutrients, and light. This interaction may be separated into categories of allelopathy and competition. Biochemical interactions which can result in an inhibitory or stimulatory effect of one plant over the other are referred to as allelopathy, while competition is generally reserved for those processes of one plant that result in the reduction or removal of a factor required by another plant for growth (Rice, 1984).

It is well know that hydrilla will colonize and dominate a body of water by excluding growth of other aquatic plants primarily through competitive effects such as reducing nutrients and light for other submersed plants. For example, hydrilla has the ability to photosynthesize under light conditions lower than that required by most other submersed plants (Van *et al.*, 1976). Hydrilla can utilize carbon dioxide early in the morning when the supply is high, and by the time the other plants receive enough light for their photosynthesis, the supply of available CO_2 has been reduced. Another competitive advantage exhibited by hydrilla is its habit of branching profusely near the surface forming a dense mat that blocks light penetration to submersed plants growing below it (Haller and Sutton, 1975).

Certain spikerush plants such as dwarf spikerush [*Eleocharis coloradoensis* (Britt.) Gilly] and slender spikerush [*Eleocharis acicularis* (L.) R. & S.] have shown allelopathic potential. These spikerushes have been found to replace elodea (*Elodea canadensis* Michx.), American pondweed (*Potamoqeton nodosus* Poir.), and sago pondweed (*Potamoqeton pectinatus* L.) through non-competitive effects (Frank and Dechoretz, 1980 and Yeo and Fisher, 1970). This allelopathic response with slender spikerush may be due to compounds with molecular weights between 600 and 1000 (Ashton *et al.*, 1985).

Established stands of the native Florida aquatic plant, slender arrowhead (*Sagittaria graminea* Michx.), were found to be more effective than the spikerush [*Eleocharis qeniculata* (L.) R. & S.] in resisting colonization of sprouted hydrilla tubers (Sutton 1986). When hydrilla was grown for 8 weeks in established stands of slender arrowhead, its shoot dry weight and tuber production were reduced as much as 95% and 90%, respectively, as compared to hydrilla cultured alone. It is not known whether allelopathy or competition was the primary factor responsible for the reduction of hydrilla growth.

In order to provide additional information on the interaction of aquatic plants, a study was conducted by allowing the Florida native arrowhead plant, *S. subulata*, (hereinafter referred to as arrowhead) to develop established stands after which sprouted tubers were planted to simulate the invasion of hydrilla. Also, since no information is available on the influence of sediment nutrients on the growth of this arrowhead plant, a portion of the study was devoted to examining its growth in sand amended with various concentrations of controlled release fertilizers. Dry weight and tuber production were the primary measurements of plant interactions.

MATERIALS AND METHODS

Culture conditions. Experiments were conducted outdoors in concrete tanks at the Fort Lauderdale Research and Education Center (FLREC). The FLREC is located at coordinates 26′05°N and 80′14′W. The dimensions of the concrete tanks were 3.1 m in width by 6.1 m in length by 0.8 m in height. The tanks were supplied with flowing pond water, water level in the tank being maintained at a height of 0.31 m. Flow was sufficient for three changes of

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water every 24 hours. Pond water was from the same source as described by Steward (1984).

Water temperatures were measured with a U-shaped maximum/minimum thermometer placed 15 cm below the surface of the water. Readings were collected from the thermometer 5 days a week, generally between 3:00 and 4:00 P.M. Temperature of the water was calculated as the mean of the minimum and maximum values measured for the growth period of each experiment.

Fertilizers[3] used for this study consisted of Osmocote (18-6-12) formulated with an 8 to 9-month release rate at a temperature of 21 C, Esmigran, and dolomite (Soil Doctor).

Arrowhead plants used in this study were from populations of plants maintained in sand amended with controlled release fertilizers in outdoor culture tanks at the FLREC. Sprouted hydrilla tubers were obtained as described by Sutton (1986).

Culture in sand amended with controlled release fertilizer. This portion of the study consisted of planting arrowhead plants in plastic culture pans with dimensions of 27 cm in width by 33 cm in length by 14 cm in height filled with 15 kg of air-dried quartz sand amended with fertilizers listed in Table 1. Each culture container was planted with five arrowhead plants and each nutrient treatment was replicated with four pans. The pans, a total of 24, were placed in four rows in the tank parallel to the flow of water with the six treatments randomized within each row. The arrowhead plants were planted May 27, 1986 and harvested on January 7, 1987. Periodically, water in the tank was drained overnight to help control growth of algae.

Culture of hydrilla in established stands of arrowhead. The arrowhead and hydrilla interaction experiment utilized 40 plastic culture containers (20 cm in height by 19 cm in diameter) in a tank. Depending on the treatment, each container was planted with five arrowhead plants or five sprouted tubers. The four treatments were (1) arrowhead plants harvested at the time the sprouted hydrilla tubers were planted, (2) arrowhead plants plus hydrilla, (3) arrowhead plants alone, and (4) hydrilla alone. Each treatment was replicated in 9 containers. Each container was filled with 6.5 kg of sand thoroughly mixed with 15.17 g of Osmocote, 0.39 g of Esmigran, and 2.43 g dolomite. The treatments were randomized within 9 rows. The pans for Treatment 4 were placed in the pool at the time of planting the arrowhead plants to account for any loss of fertilizer which might occur during the initial growth of the native plants. Prior to planting the hydrilla, the tank was periodically drained overnight to help reduce growth of algae.

Harvest of plants. At harvest time the plants were removed from the culture container and washed with pond water to remove algae, sand, and other adhering debris.

[3]Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the University of Florida and does not imply its approval to the exclusion of other products that also may be suitable. Osmocote is manufactured by Sierra Chem. Co., Milpitas, CA 95035, Esmigran by Mallinckrodt, Inc., St. Louis, MO 63147, and dolomite (Soil Doctor) by Soil Doctor, Inc., Crystal River, FL 33004.

TABLE 1. FERTILIZERS ADDED TO SAND FOR CULTURE OF ARROWHEAD PLANTS DURING THE PERIOD OF MAY 27, 1986 to JANUARY 7, 1987.

	Amount of fertilizer (g)		
Treatment	Osmocote	Esmigran	Dolomite
Sand only	0	0	0
Sand plus fertilizer	2.5	0.1	0.7
Sand plus fertilizer	5.0	0.3	1.4
Sand plus fertilizer	15.0	0.5	2.8
Sand plus fertilizer	25.0	0.7	4.2
Sand plus fertilizer	35.0	0.9	5.6

The hydrilla plants were separated into shoot and root portions, and the number of tubers counted. The plants and tubers were dried to a constant weight at 60 C.

Collection of arrowhead plants from the Wakulla River. Arrowhead plants were collected January 22, 1989 from field populations of plants growing along the banks near the mouth of the Wakulla River. A total of six samples were collected by removing all the plant material, including the shoots and roots, from within a surface area of 284 cm^2. The plants within the area were washed and dried to a constant weight at 60 C.

Statistical analyses of results. Linear regression procedures were used to relate arrowhead dry weight to the level of Osmocote added to the sand culture medium. For statistical evaluation of hydrilla culture in established stands of arrowhead plants, Analysis of Variance (ANOVA) procedures were used on dry weight measurements and tuber numbers. Count data for the tubers were transformed by adding 1 to each value and then taking its natural log prior to analyses; however, the non-transformed values are presented. Mean separation was accomplished using the least significant difference (LSD) procedure. The average and standard deviation were determined for the six samples plants collected from the Wakulla River, and then converted to plant dry weight per m^2.

RESULTS AND DISCUSSION

Water temperature averaged 29 C with a minimum of 16.5 C and a maximum of 46.5 C for the arrowhead plants cultured during the period of May 27, 1986 to January 7, 1987. Under natural culture conditions, it is not uncommon for this arrowhead plant to be exposed to drying conditions during low tides (Godfrey & Wooten, 1981). Therefore, it is assumed that the periodic drying of the arrowhead plants to control algae growth did not interfere with their growth.

Dry weights of the arrowhead plants cultured in sand amended with the various levels of fertilizer are shown in Figure 1. Arrowhead plants cultured in sand alone produced 0.7 g of total plant dry weight per culture container. Statistical analysis for the relationship of plant dry weight (the independent variable) to the level of Osmocote (the dependent variable) resulted in a F- value of 48.94 ($p=0.0001$). At the 35 g of Osmocote per container, plant dry weight was estimated at 69 g per m^2.

Dry weight for arrowhead plants collected from the Wakulla River estimated at 646 ± 184 g per m^2, and repre-

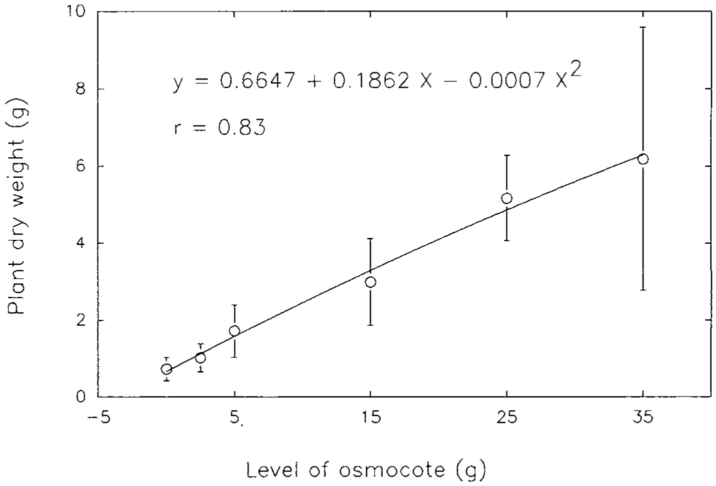

Figure 1. Dry weight of arrowhead plants cultured outdoors for the period of May 27, 1986 to January 7, 1987 in various levels of fertilizer as listed in Table 1. Only the level of Osmocote is listed along the X axis. Refer to Table 1 for respective amounts of Esmigran and Dolomite.

sents a 9-fold higher difference as compared to those plants cultured in the sand with the high level of fertilizers. These data suggest that a longer culture period, additional fertilizer, or other unknown factors would be required to achieve similar growth of the arrowhead plants under semi-controlled culture conditions at the FLREC as compared to growth of this plant under natural conditions.

For the interaction experiment, the water temperature averaged 29.2 C with a minimum of 14.0 C and a maximum of 46.5 C during the period of February 19 to September 25, 1986 when the arrowhead plants were allowed to become established. After the hydrilla was planted, the water temperature averaged 29.4 C with a minimum of 23.0 C and a maximum of 34.0 C for the period of September 25 until November 20, 1986.

TABLE 2. DRY WEIGHT AND NUMBER OF TUBERS FOR HYDRILLA CULTURED FROM SEPTEMBER 25 TO NOVEMBER 20, 1986 IN ESTABLISHED STANDS OF ARROWHEAD PLANTS. ARROWHEAD PLANTS ALLOWED TO ESTABLISH DURING THE PERIOD OF FEBRUARY 19 TO SEPTEMBER 25, 1986.[a]

	Plant dry weight (g)				
		Hydrilla			
Growth condition	Arrowhead	Shoot	Root	Number of hydrilla tubers	Hydrilla tuber weight (g)
Prior	1.54	–	–	–	–
With	1.58	24.5 •	4.9	107	0.05
Alone	2.18	–	–	–	–
Alone	–	43.7	6.3	259	0.04
LSD	0.64	5.8	1.6	47	0.005
Pr>F	0.1718	0.0001	0.0974	0.0001	0.0004
Root MSE	0.6567	6.1308	1.6587	50.9182	0.0057

[a]Each value is the mean of 9 culture pans. Tuber weight determined by dividing the weight for each container by the number of tubers in each.

Shoot weight of hydrilla plants grown in pans without arrowhead plants were 1.8 times heavier than shoots of hydrilla planted in the established stands of arrowhead. However, no difference in root weight was observed.

The number of tubers per culture container was 59% lower for hydrilla planted in the established stands of arrowhead plants as compared to hydrilla cultured alone. Also, dry weight of the tubers from the hydrilla plants grown with the arrowhead plants was 3 times lower than for the hydrilla alone. The average tuber weight was 20% lower for those collected from hydrilla cultured with the arrowhead plants as compared to the tubers from hydrilla plants cultured alone.

It is not unusual to find populations of arrowhead occurring as small monocultures in various bodies of water in Florida. Even though the arrowhead plants exhibited a slow growth rate as compared to hydrilla, and a low biomass as compared to plants collected from field population, this study does show that this submersed arrowhead plant will resist the initial colonization by hydrilla. Long-term growth studies however will be required to determine the nature of the interaction of these two species and the eventual outcome of the competing arrowhead and hydrilla plants.

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