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Growth of Dioecious Hydrilla in Sediments from Six Florida Lakes[1]

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ABSTRACT

Dioecious hydrilla (*Hydrilla verticillata* (L.f.) Royle) was cultured outdoors in tanks in south Florida for four separate 16-week culture periods using sediments collected four different times from two sites each in East Lake Tohopekaliga, Lake Tohopekaliga, Cypress Lake, Lake Hatchineha, Lake Kissimmee and Lake Okeechobee. Differences in growth of hydrilla as determined by dry weight occurred both for between- and within-lake sediment collection times. Total dry weight of hydrilla plants cultured in sediments from Site 2 in Cypress Lake for the first three culture periods produced an average of 73 g, 203 g, and 99 g per culture container and was higher than plants cultured in any of the other sediments. For the fourth culture period, however, dry weights of hydrilla cultured in sediments from both sites in Lake Hatchineha were similar to those cultured in sediments from Site 2 in Cypress Lake. Dry weight of hydrilla cultured in sediments from East Lake Tohopekaliga, Lake Kissimmee, and Site 1 of Lake Okeechobee was consistently low for the four culture periods. For example, hydrilla cultured on sediments from Site 1 in Lake Okeechobee produced an average of 4 g, 14 g, 4 g, and 2 g per culture container during the four culture periods. Subterranean turions (tubers) were produced during two of the culture periods. The highest number of tubers, equivalent to 1,253 and 1,976 tubers per m^2, were produced in sediments from Sites 1 and 2 of Cypress Lake, respectively, during December 5, 1988 to March 27, 1989. Individual tuber weights averaged 50 mg each and were similar for all sites in all lakes for both culture periods. The ratio of root:shoot dry weight was less than 1 for hydrilla plants cultured on sediments from the six lakes for all four culture periods except for Site 1 in East Lake Tohopehaliga and Sites 1 and 2 in Lake Kissimmee during the July 6 to October 26, 1987 culture period. High dry weight values were related to low root:shoot ratios and low hydrilla weights to high ratios. These data suggest that substantially different amounts of hydrilla growth can be expected to occur both within and among in these six Florida lakes.

Key words: Submersed aquatic plant, nutrients, tubers, East Lake Tohopekaliga, Lake Tohopekaliga, Cypress Lake, Lake Hatchineha, Lake Kissimmee, Lake Okeechobee.

INTRODUCTION

Hydrilla is a major aquatic weed problem in Florida, and has increased dramatically since its introduction more than 25 years ago (Blackburn et al. 1969). During the 1990 annual survey of public waters by the Florida Department of Environmental Protection (formerly the Department of Natural Resources (Schardt and Schmitz 1991), hydrilla was found in 23,081 ha compared to 5,314 ha in 1982 (Schardt and Nall 1983). This increase in hydrilla has occurred despite control efforts with herbicides and grass carp (*Ctenopharygodon idella* Val.).

Barko et al. (1991) reviewed the literature on the importance of sediments and open water on nutrient availability for growth of submersed aquatic plants. In general, sediments are the primary source for nitrogen, phosphorus, iron, manganese and micronutrients while open water provides calcium, magnesium, sodium, potassium, sulfate, and chloride. However, a number of factors are involved in the establishment and growth of submersed aquatic plants.

To provide additional information on growth of hydrilla, we cultured hydrilla on sediments collected four separate times from six lakes in Florida. The goal of this study was to evaluate growth of hydrilla on sediments from different lakes in an attempt to determine its potential for growth in these aquatic systems.

MATERIALS AND METHODS

Sediments were collected to a depth of 16 cm with the core sampler described by Sutton (1982) from two sites each in East Lake Tohopekaliga, Lake Tohopekaliga, Cypress Lake, Lake Hatchineha, Lake Kissimmee, and Lake Okeechobee (Figure 1). At each site, sufficient sediment was collected to fill four plastic containers each with dimensions of 20 cm in height by 19 cm in diameter. Containers were capped for transport to the Fort Lauderdale Research and Education Center (FLREC). Sediments were collected from the 12 sites over a 2- to 4-day period in 1986, 1987, 1988, and 1989.

Sediments were processed dry using procedures described by Sutton (1990). Sediments were air-dried outdoors in the un-capped, plastic containers until no obvious water could be seen, and then were placed for 3 weeks in a forced-air drying oven at 60 C. Dried sediment in the four containers for

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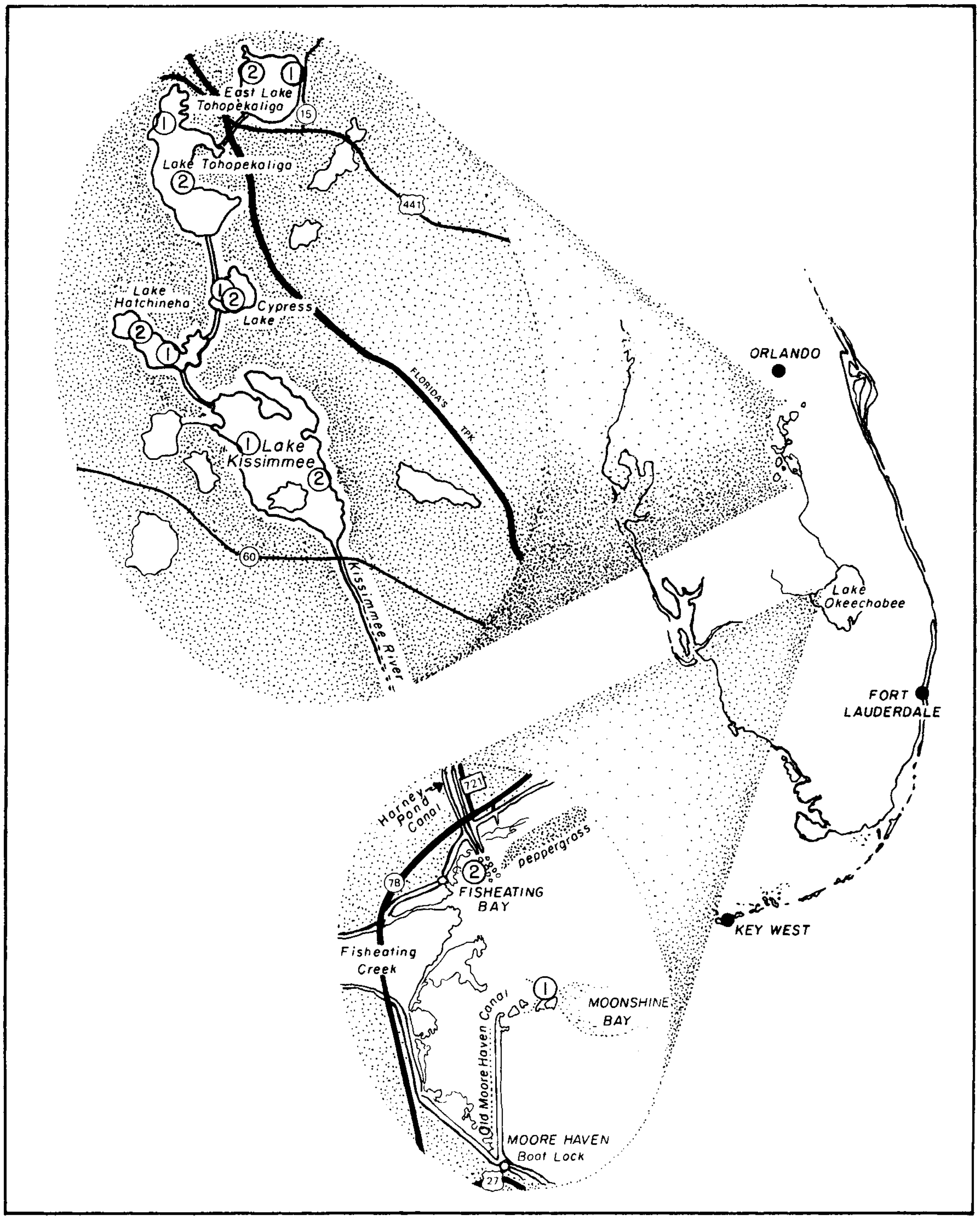

Figure 1. Location of sites for collection of sediments from six Florida lakes used in culture of hydrilla in outdoor tanks in south Florida. Site locations, 1 or 2 for each lake, are enclosed by circles.

each site for each collection time was ground individually in a Model 201 XL Holms Hammermill Crusher[3] with a mesh screen composed of holes 0.476 cm in diameter set 0.24 cm apart. The processed sediments were returned to the plastic containers, capped, and stored at room temperature until needed for culture of hydrilla. Sediment in each container weighed 4.5 kg except for the June 1 to September 21, 1988 culture period when the sediment placed in each container weighed 5.8 kg.

Hydrilla was cultured outdoors in cement tanks with flowing pond water at the FLREC using methods described by Sutton (1986). Flow of pond water, from the same source described by Steward (1984), was sufficient to provide for a complete exchange of tank volume every 24 hours.

Prior to culture of hydrilla, the sediments were placed in culture containers (dimensions of 20 cm in height by 19 cm in diameter) arranged in a tank in four rows. Sediments from all 12 sites were randomized within each row, and each row was placed perpendicular to the flow of pond water. This arrangement allowed for four replications of each site for each culture period.

Hydrilla tubers were allowed to sprout in pond water for 4 to 5 weeks. When the shoots of these tubers were approximately 12 cm in length they were planted four each in the culture containers and allowed to grow for 16 weeks. Culture periods were July 6 to October 26, 1987; June 1 to September 21, 1988; December 5, 1988 to March 27, 1989. Water temperatures were recorded during each culture period as described by Sutton (1986).

Once hydrilla plants reached the surface of the water, an emulsifiable concentrate of malathion (0,0-dimethyl dithiophosphate of diethyl mercaptosuccinate) was added to achieve a concentration of 1.0 mg/L as necessary to control feeding activity of the herbivorous moth, *Parapoynx diminutalis* Snellen. Also, periodically the tank was cleaned with a siphon to remove debris or algae on the bottoms and sides.

At the end of each culture period, plants were removed from the tank and washed with pond water to remove adhering sediment and other debris. Subterranean turions (hereafter called tubers) were counted when present. Plants were separated into an above-sediment portion (hereafter called shoots), and a below-sediment portion consisting of roots and rhizomes (hereafter called roots). Tubers and plant material were dried to a constant weight in a forced-air drying oven at 60 C.

For each culture period, plant dry weight and number of tubers, were analyzed using the GLM (general linear model) procedure of SAS (Statistical Analysis System 1989). Hydrilla dry weights were converted to natural logs because of the wide range of dry weight values for a culture period, and tuber count data were transformed by using the square root of the count plus one as suggested by Steel and Torrie (1960) The Waller-Duncan Bayesian LSD procedure was used for mean separation for dry weight and tuber values. Regression analysis was used to evaluate the association between the number of tubers produced and hydrilla dry weight.

RESULTS AND DISCUSSION

Mean water temperatures of 29.4 to 30.6 C were measured for three of the four culture periods with a mean of 23.8 C for the December 5, 1988 to March 27, 1989 culture period. The high mean temperatures are in the upper range for growth of hydrilla as suggested in the study by Van et al. (1978).

Between-lake and within-lake differences for dry weight values were observed for hydrilla plants cultured on sediments from the six Florida lakes (Figure 2). Since it was difficult to return to the same exact location for sampling each year, lack of uniformity within sampling locations may have contributed to these observed dry weight differences. Also, water temperature probably contributed to observed dry weight differences. For example, water temperature for the June 1 to September 21, 1988 cultured period averaged 31 C while the temperature for December 5, 1988 to March 27, 1989 averaged 24 C, and the total dry weight for all sediment treatments was 1,737 g and 972 g, respectively, showing the higher weight was associated with the higher water temperature.

Total dry weight (shoots plus roots) for hydrilla plants cultured in sediments from Site 2 in Cypress Lake for the first three culture periods produced an average of 73 g, 203 g, and 99 g per culture container and was higher than plants cultured in any of the other sediments (Figure 2). For the fourth culture period, dry weight of hydrilla cultured in sediments from both sites in Lake Hatchineha were similar to those cultured in sediments from Site 2 in Cypress Lake.

In general, dry weight of hydrilla cultured in sediments from East Lake Tohopekaliga, Lake Kissimmee, and Site 1 of Lake Okeechobee were consistently low for the four culture periods (Figure 2). For example, dry weights of hydrilla cultured in sediments from Site 1 in Lake Okeechobee were 4 g, 14 g, 4 g, and 2 g per culture container during the four culture periods.

Photoperiod (Van et al. 1978) was conducive for tuber production during the July 6 to October 26, 1987 and December 5, 1988 to March 27, 1989 culture periods (Figure 3). Individual tubers averaged 50 mg dry weight and were similar in weight for sediments from both sites in all lakes for the two culture periods.

Hydrilla cultured July 6 to October 26, 1987 and December 5, 1988 to March 27, 1989 produced only 1 to 20 tubers per culture container on sediments from East Lake Tohopekaliga, Lake Kissimmee, and Site 1 in Lake Okeechobee. The small numbers of tubers produced by hydrilla in sediments from Lake Okeechobee are consistent with previously published data (Sutton and Portier 1985, and Sutton 1990); however, no information is available to make comparisons on expected tuber production by hydrilla cultured in sediments from the other five Florida lakes.

No differences in numbers of tubers per culture container were observed for hydrilla grown in sediments from both sites in Lake Tohopekaliga, Cypress Lake, and Site 1 of Lake Hatchineha during the July 6 to October 26, 1987 culture period. During the December 5, 1988 to March 27, 1989 culture period, hydrilla cultured in sediments from Cypress Lake produced 71 and 112 per culture container, for Sites 1 and 2 respectively. Based on the surface area of the culture containers, 71 and 112 tubers per container was calculated to be equivalent to 1,253 and 1,976 tubers per m^2, respectively. This equivalent number of tubers is 51% and 24% less, respectively than the average number of 2,600 tubers per m^2 produced by dioecious hydrilla cultured in sand amended with fertilizer contained in 1.0 m^2 boxes held under outdoor south Florida conditions (Sutton et al. 1992).

The regression relationship of number of tubers per culture container to total plant dry weight is presented in Figure 4. For our study, the number of tubers produced was highly dependent on the total dry weight of the hydrilla cultured in sediments from the six lakes.

The ratio of root:shoot dry weight was less than 1 for hydrilla plants cultured on sediments from the six lakes for all

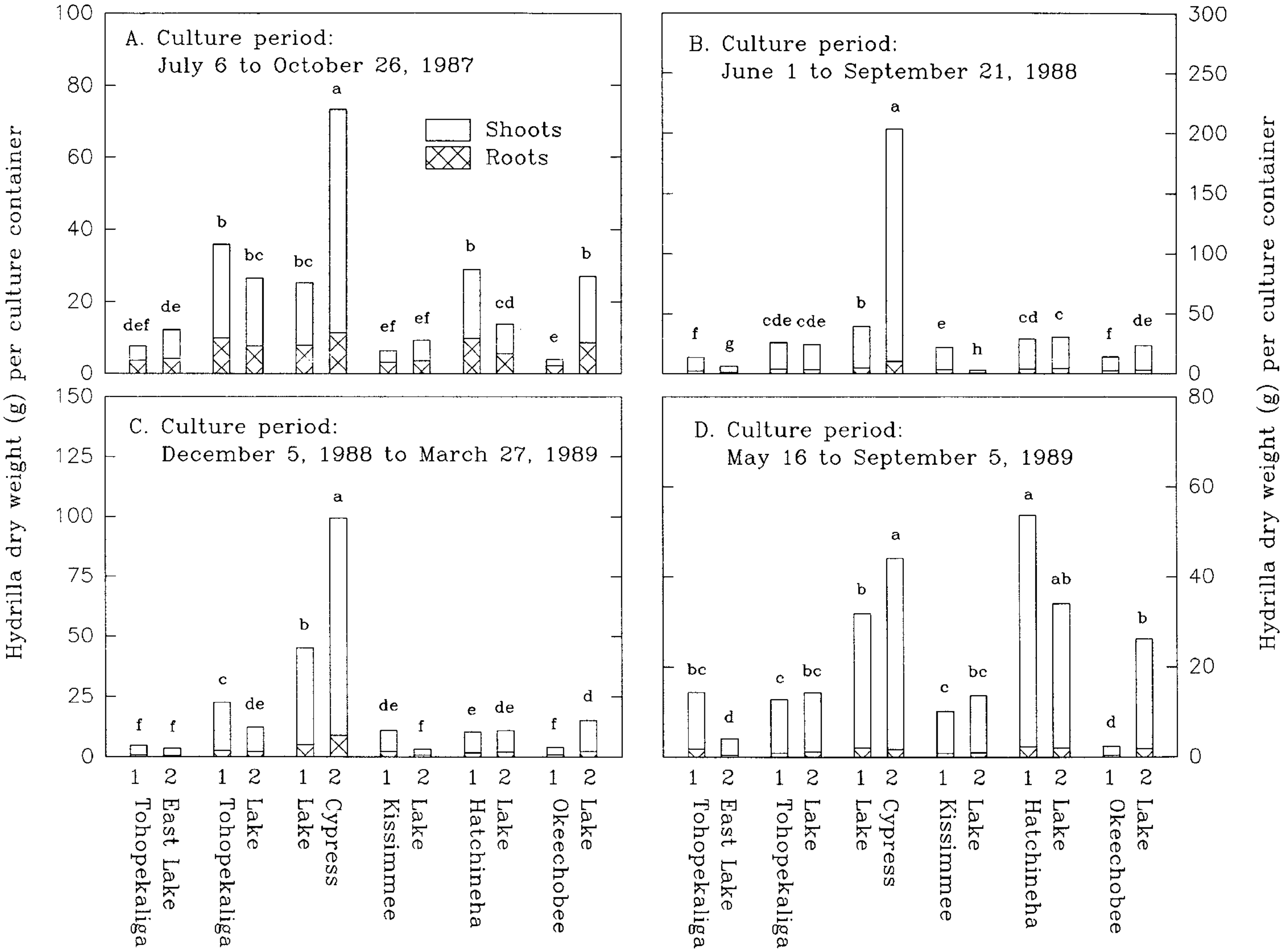

Figure 2. Dry weight of hydrilla cultured in sediments from six Florida lakes placed in outdoor tanks in south Florida. Each bar represents the mean of four culture containers. Similar letters at the top of the bars for each culture period indicate no statistically significant difference for total weight at $P < 0.001$ according to the Waller-Duncan Bayesian procedure.

four culture periods except for Site 1 in East Lake Tohopekaliga and Sites 1 and 2 in Lake Kissimmee during the July 6 to October 26, 1987 culture period. High dry weight was related to low root:shoot ratios and low hydrilla weight to high ratios. Barko et al. (1991) suggest that root:shoot ratios in excess of 1 for some submersed species are an indication of infertile environments. Since root:shoot ratios were both above and below 1 in our study, these data suggest that substantially different amounts of hydrilla growth, ranging from quite high to low depending on lake and location within the lake, can be expected to occur in these six Florida lakes.

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LITERATURE CITED

Barko, J. W., D. Gunnison, and S. R. Carpenter. 1991. Sediment interactions with submersed macrophyte growth and community dynamics. Aquat. Bot. 41:41-65.

Blackburn, R. D., L. W. Weldon, R. R. Yeo, and T. M. Taylor. 1969. Identification and distribution of similar appearing aquatic weeds in Florida. Hyacinth Control J. 8:11-21.

Schardt, J. D. and D. C. Schmitz. 1991. 1990 Florida Aquatic Plant Survey. Technical Report No. 91-CGA. Florida Department of Natural Resources. Tallahassee. . 89 pp.

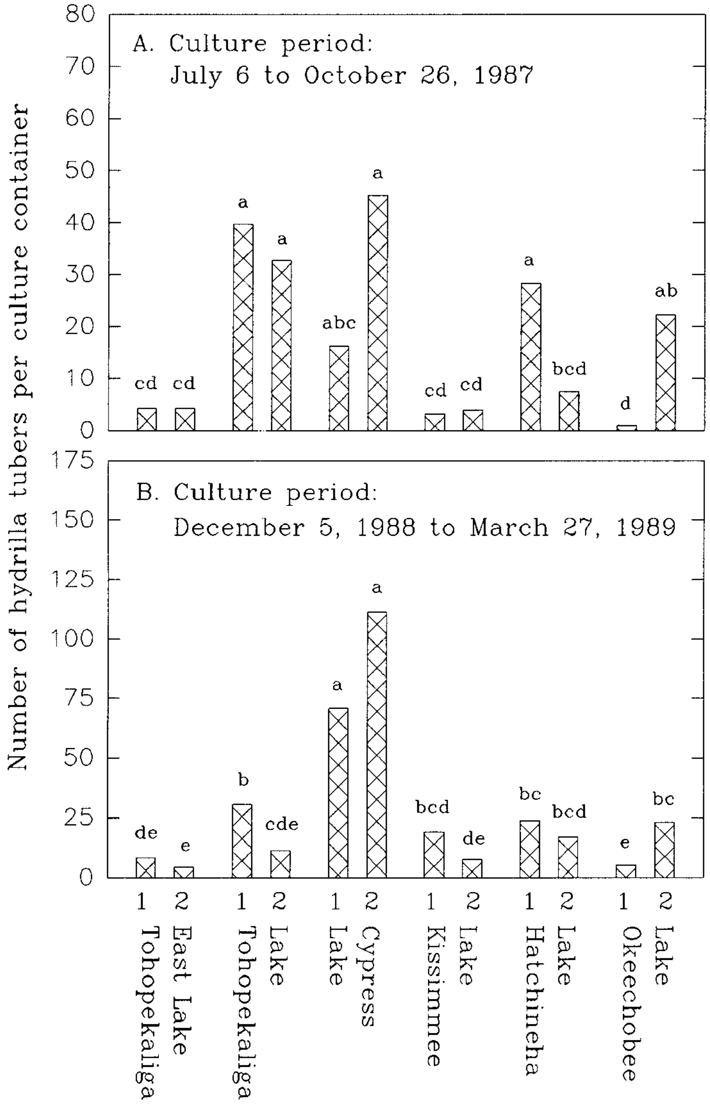

Figure 3. Number of tubers produced by hydrilla cultured in sediments from six Florida lakes placed in outdoor tanks in south Florida. Each bar represents the mean of four culture containers. Similar letters at the top of the bars for each culture period indicate no difference for number of tubers at P < 0.001 according to the Waller-Duncan Bayesian procedure.

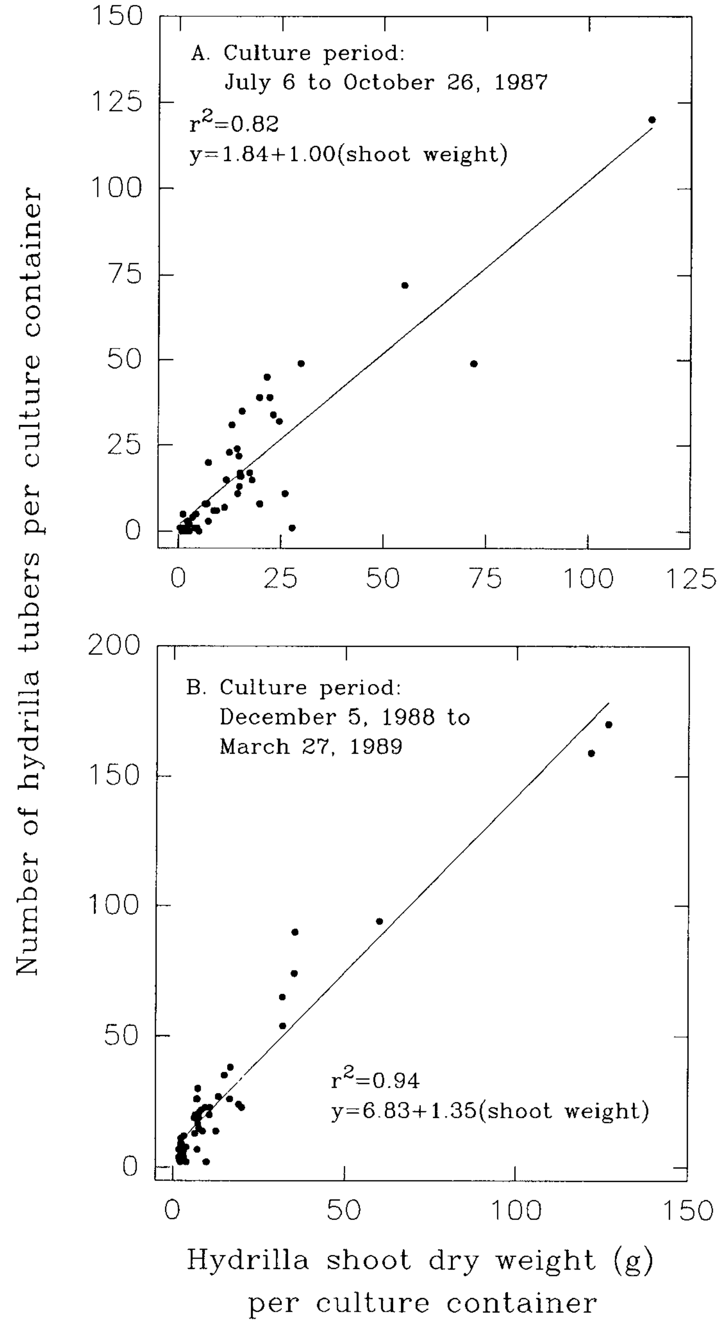

Figure 4. Relationship of number of tubers produced to total plant dry weight for hydrilla cultured in sediments from six Florida lakes placed in outdoor tanks in south Florida.

Schardt, J. D. and L. E. Nall. 1983. 1982 Aquatic Flora of Florida Survey Report. Bureau of Aquatic Plant Research and Control. Florida Dept. of Natural Resources, Tallahassee. 116 PP

Statistical Analysis System. 1989. SAS Institute, Cary, North Carolina, USA.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics with Special Reference to the Biological Sciences. McGraw-Hill Book Company, Inc., N. Y. 479 pp.

Steward, K. K. 1984. Growth of hydrilla (*Hydrilla verticillata*) in hydrosoils of different composition. Weed Sci. 32:371-375.

Sutton, D. L. 1982. A core sampler for collecting hydrilla propagules. J. Aquat. Plant Manage. 20:57-59.

Sutton, D. L. 1986. Culture of hydrilla (*Hydrilla verticillata*) in sand root media amended with three fertilizers. Weed Sci. 34:34-39.

Sutton, D. L. 1990. Comparison of two methods for evaluating growth of hydrilla in sediments collected from Lake Okeechobee. J. Aquat. Plant Manage. 28:80-83.

Sutton, D. L. and K. M. Portier 1985. Density of tubers and turions of hydrilla in South Florida. J. Aquat. Plant Manage. 23:64-67.

Sutton, D. L., T. K. Van., and K. M. Portier. 1992. Growth of dioecious and monoecious hydrilla from single tubers. J. Aquat. Plant Manage. 30:15-20.

Van, T. K., W. T. Haller, and L. A. Garrard. 1978. The effect of day length and temperature on hydrilla growth and tuber production. J. Aquat. Plant Manage. 16:57-59.