J. Aquat. Plant Manage. 63(1): 27–29

Note

Growth of eight Florida ecotypes of Illinois pondweed under common nursery conditions

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INTRODUCTION

Many water resource managers and state agencies, including the Florida Fish and Wildlife Conservation Commission (FWC), implement aquatic habitat restoration and enhancement projects to reverse changes caused by altered hydrological patterns resulting from water management and control efforts. These projects include replanting impaired areas with native aquatic plants, which provides a host of benefits. Submersed aquatic vegetation (SAV) improves fisheries by providing habitat, vegetative cover, and a food source (Wiley et al. 1984, Maceina 1996, Havens et al. 2005, Hanlon and Jordan 2023). Also, SAV can reduce turbidity, increase water clarity, and uptake carbon and other nutrients (Barko and Smart 1981, Madsen et al. 2001).

Many restoration projects specify "local provenancing" (using locally sourced plant material), with the assumption that these taxa are adapted to the environment from which they were derived and inherently better suited to a particular area than plants collected elsewhere (Bucharova et al. 2017 and references within). However, many aquatic systems targeted for restoration are degraded with environmental conditions that are very different from less-degraded nearby waterbodies that may serve as sources for restoration materials. Therefore, locally collected plant material may not fare well when transplanted from a healthy system into a degraded one. Instead, native plants from different ecosystems—hereafter referred to as "ecotypes"—may perform better at the transplant site, particularly if they are more tolerant of a wide range of environmental conditions. Another issue that can hamper revegetation efforts is availability of adequate amounts of native plant material for use in restoration projects. Many species of SAV are field collected, which can be time consuming, expensive, and disruptive to existing ecosystems. Both of these concerns can be addressed by performing common nursery trials.

Common nursery studies manipulate environmental factors such as fertilizer rate and substrate composition to identify favorable growing conditions for a particular species or cultivar of plant (Broschat and Moore 2001). Quantitative data such as shoot weight, root weight, and overall plant height can be used to measure the effectiveness of experimental factors (Gettys and Moore 2018). Thus, common nursery studies can be used to evaluate the performance of ecotypes under a range of conditions, which could potentially identify plant material that is likely to establish in degraded systems targeted for restoration (Caldwell et al. 2011), and to optimize culture conditions and maximize production of plants for restoration projects, which would reduce the need for field collection of plant material.

A diversity of native macrophytes can be used in aquatic habitat restoration and enhancement projects, but of particular interest to resource managers in Florida is Illinois pondweed (*Potamogeton illinoensis* Morong). Illinois pondweed provides a number of environmental benefits; in addition to stabilizing substrates and reducing waterborne nutrients, vegetative parts of the species provide refugia and food for fish (Dibble 2020), whereas the carbohydrate-rich fruits are a preferred food source for waterfowl (Wersal and Getsinger 2020). This North American native submersed plant that has been vouchered from Puerto Rico to the Arctic Circle (U.S. Department of Agriculture—Natural Resources Conservation Service [USDA-NRCS] 2024). The wide distribution of Illinois pondweed suggests it is tolerant of a variety of environments, which, coupled with its ecosystem benefits, makes it a great candidate for restoring lakes that have scarce quantities of native SAV.

Despite a preference for using locally sourced plants for revegetation programs, aquatic systems that are selected for restoration and habitat enhancement may lack large, robust populations of Illinois pondweed to serve as donor sites. In these experiments, we evaluated ecotypes of Illinois pondweed under common nursery conditions to identify ecotypes that might perform well in restoration plantings and to provide guidance to aquatic nurseries wishing to grow Illinois pondweed for use in these projects.

MATERIALS AND METHODS

Plant material

We evaluated eight ecotypes of Illinois pondweed collected throughout Florida, United States, in these experiments. Plants were collected from Dinner Lake (Sebring/Highlands

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DOI: 10.57257/JAPM-D-24-00015

County), Lake Pierce (unincorporated Polk County), Lake Okeechobee (Palm Beach, Martin, Glades, Okeechobee, and Hendry Counties), Okeeheelee Park (West Palm Beach/Palm Beach County), Lake Howard (Winter Haven/Polk County), Lake Tarpon (unincorporated Pinellas County), East Lake Tohopekaliga (Osceola County), and Lake Virginia (Winter Park/Orange County). Samples of each ecotype were sent to Dr. Ryan Thum (Ecological Genetics and Genomics of Aquatic and Invasive Plants Laboratory, Montana State University), who used molecular genetic tools to confirm that all plant material was indeed the native *P. illinoensis*.

Substrates and fertility

Mixes of commercially available peat[1] and coarse builder's sand were blended to create a series of five artificial substrates with a range of organic matter contents. Substrate mixes included 100% sand; 75% sand + 25% peat (v/v); 50% sand + 50% peat (v/v); 25% sand + 75% peat (v/v); and 100% peat. Four nutrient levels were utilized in these studies, with fertility supplied by a controlled-release fertilizer.[2] Nutrient treatments included control (no fertilizer), low (1 g L^{-1}), medium (2 g L^{-1}), and high (4 g L^{-1}) rates. Substrate mixtures were thoroughly blended and fertilizer was incorporated in the lower 7 cm of containers in treatments that specify nutrient amendment.

Experimental conditions and analysis

Each experimental unit was a single 2-L HDPE container without holes that was filled to the top of the container (final substrate volume approximately 2 L) and planted with 10 apical cuttings (each 15–25 cm long) of the same ecotype. Four replicate containers were prepared for each ecotype–substrate–nutrient level combination. All containers were top-dressed with a 3-cm layer of washed pea gravel to prevent loss of substrate. Experiments were run once and initiated between November 2021 and February 2022 and concluded between March and June 2022. All experiments took place in an unheated greenhouse under ambient air temperature and light conditions at the University of Florida Fort Lauderdale Research and Education Center in Davie, Florida. Experimental units were placed in 2.5-m-diam tanks filled with well water and maintained at a depth of 0.5 m. Eight tanks were used, and each tank housed all substrate-fertility combinations and replicates of a single ecotype (i.e., 80 units per tank). Each tank was equipped with a biofilter[3] operated by a 2,728 L h pond pump to circulate water and reduce algal blooms.

Plants were cultured for 16 wk, then the longest stem in each container was measured. A destructive harvest was conducted to separate and collect all aboveground stems and all belowground roots at the substrate line. Plant tissue was washed clean of substrate and other debris and dried in a forced-air oven at 65°C until a constant weight was achieved. Raw data were subjected to ANOVA and Fisher's Protected LSD test separation using SAS 9.4 software.[4] The general linear model included ecotype, substrate, and fertility level as independent variables. Dependent variables were longest stem length, shoot dry biomass, root dry biomass, and total dry biomass.

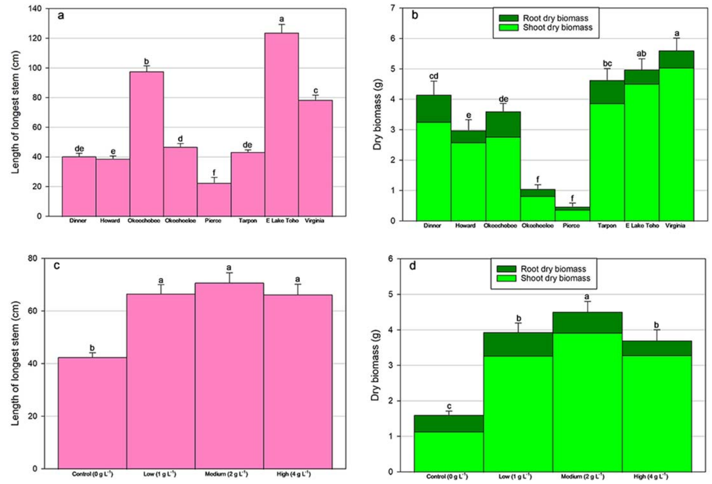

Figure 1. Effect of ecotype and fertilizer rate on growth of eight Florida ecotypes of Illinois pondweed. Bars represent the mean of 80 (ecotype) or 160 (fertilizer rate) replicates, and error bars represent one standard error from the mean. Treatments coded with the same letter are not significantly different at $P = 0.05$. (a) Effect of ecotype on length of longest stem. (b) Effect of ecotype on dry biomass; letters indicate differences in total dry biomass. (c) Effect of fertilizer rate on length of longest stem. (d) Effect of fertilizer rate on dry biomass; letters indicate differences in total dry biomass.

RESULTS AND DISCUSSION

Ecotype and fertility level affected Illinois pondweed growth in these experiments. However, substrate composition did not influence pondweed growth ($P = 0.0632$).

Ecotype

Ecotype had a significant effect on pondweed productivity (stem length $P < 0.0001$; total dry biomass $P < 0.0001$) in these experiments. Longest stems (average length 123.8 cm) were produced by the East Lake Toho ecotype (Figure 1a). There was no difference in total dry weight between the East Lake Toho and Lake Virginia ecotypes (5.0 g and 5.61 g, respectively), but total dry weights of these two ecotypes were higher than those of the six other ecotypes (Figure 1b).

Fertility level

As with ecotype, fertility level had a significant effect on productivity of these Florida ecotypes of Illinois pondweed (stem length $P < 0.0001$; total dry biomass $P < 0.0001$). There was no difference in longest stem length of plants cultured with the low (1 g L^{-1}), medium (2 g L^{-1}), or high (4 g L^{-1}) rate of fertilizer, but stems were shortest in pondweed grown with the control (no fertilizer) rate (Figure 1c). Total dry weight was highest in plants grown with the medium (2 g L^{-1}) rate of fertilizer (Figure 1d).

These experiments revealed that growth of Illinois pondweed is affected by ecotype (plant source), at least for the Florida taxa examined in these experiments. This has important implications for producers charged with growing the plant material for aquatic restoration projects and for the managers directing these projects. As mentioned in the foregoing, restoration and revegetation plans often specify that locally sourced plant material be used, but nearby populations of the desired species may be sparse, nonexistent, or ill-suited for the system targeted for restoration. This research shows that ecotype selection should be considered when developing revegetation projects that include Illinois pondweed, as not all members of this species are created equal. We also report that Florida ecotypes of Illinois pondweed produce the longest stems when grown with any amount of fertilizer and that the greatest biomass occurred in plants cultured with a moderate (2 g L^{-1}) rate of fertilizer. This information, coupled with our findings regarding ecotype performance, may be useful to nurseries and growers wishing to optimize their production of Illinois pondweed being grown for aquatic restoration projects.

SOURCES OF MATERIALS

[1]Majestic Earth Sphagnum Peat Moss, SunGro Horticulture, 770 Silver Street, Agawam, MA 01001.

[2]Southern Formula Osmocote Plus, 15–9–12 N–P–K, formulated for 5 to 6–mo release, ICL Fertilizers, 4950 Blazer Memorial Parkway, Dublin, OH 43017.

[3]ClearChoice Biofilter PF-1, Tetra/United Pet Group Aquatics, 3001 Commerce Street, Blacksburg, VA 24060.

[4]SAS Version 9.4, SAS Institute, 100 SAS Campus Drive, Cary, NC 27513.

ACKNOWLEDGEMENTS

Funding for this research was provided by the Florida Fish and Wildlife Conservation Commission, Aquatic Habitat Restoration and Enhancement Subsection. We thank Beacham Furse for his oversight of this project, the many FWC biologists that helped with field collection of plant material, and our lab interns for assistance with this project. We also thank Dr. Ryan Thum of Montana State University for genetic analysis and species confirmation of the Illinois pondweed ecotypes evaluated in these experiments.

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