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Growth of Texas Wildrice (*Zizania texana*) in Three Sediments from the San Marcos River

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ABSTRACT

A conservation population of the endangered Texas wildrice has been maintained in an outdoor raceway on the Southwest Texas State University campus since 1986. To determine a suitable planting medium for raceway grown plants, seeds were germinated, then planted in three soils: clay, sandy clay loam, and gravel. After 6 weeks of growth, plants were dried, separated into above and below ground parts and weighed. Plants produced the greatest biomass in sandy clay loam and the least in clay. Plants grown in clay (with intermediate nutrient concentration) had the highest r:s, 0.74, which suggests sediment texture as well as nutrient concentration may play an important role in growth of this endangered species.

Key words: macrophyte, nutrient concentration, Texas wildrice, *Zizania texana*, root to shoot ratio, endangered species.

INTRODUCTION

Texas wildrice (*Zizania texana* Hitchc.) is an emergent aquatic macrophyte in the family Poaceae. Its distribution is limited to the first 2.4 kilometers of the spring fed, thermally constant San Marcos River, Hays County, Texas. Texas wildrice typically occurs adjacent to the deepest part of the river channel in gravel or soft, muddy sediments forming dense stands which vary in aerial coverage from approximately 0.45 m^2 to 194 m^2 (Texas Parks and Wildlife Department 1990).

Texas wildrice is listed as an endangered species by both U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department. Factors which threaten its survival include reduced spring flow from the San Marcos springs, reduced water quality in the San Marcos River, competition and predation by nonnative species such as Nutria (*Myocaster coypus*) and *Hydrilla verticillata*, absence of sexual reproduction in the wild, and alteration of sediments in the river bottom (U.S. Fish and Wildlife Service 1984). Alteration of the river sediments includes deposition of fine organic and inorganic particles due to reduction in frequency and magnitude of historic flooding cycles, and coarse gravel deposition from soil erosion in the immediate water shed. To protect plants from extinction from threats in the wild and also for research purposes, attempts have been made to propagate Texas wildrice outside the San Marcos River. Terrell et al. (1978) had limited success growing mature Texas wildrice plants in Beltsville, Maryland. Emery (1977) briefly grew Texas wildrice in an outdoor raceway on the Southwest Texas State University (SWT) campus, San Marcos, Texas; but, they were not maintained after Emery's retirement in the late 1970's. In 1986 Power collected small clumps of Texas wildrice from the San Marcos River which were planted in peat pots containing native sediments and placed in flowing water on the SWT campus. A conservation population of Texas wildrice has since been maintained on the SWT campus.

Growth by Texas wildrice is significantly influenced by the sediment in which it is grown (Power and Fonteyn 1995). It is unknown, however, to what extent nutrients and sediment, separately or in combination, influence plant growth. This study was initiated to elaborate on the nutritional requirements of Texas wildrice and the potential role sediment texture may play in plant growth. The objective was to determine growth response by Texas wildrice when grown in sediments collected from the species' natural habitat. The research will improve our understanding of the ways in which sediments effect plant growth; and, it may benefit decisions on management with respect to the conservation population, habitat alteration of the San Marcos River and watershed, and future reintroduction programs of this endangered species.

METHODS AND MATERIALS

Three sediment types were selected for the growth experiment, 1) a moderately fine sediment from Sewell Park in the San Marcos River; 2) a coarse sediment from the confluence of Sessom Creek and the San Marcos River; and, 3) a very fine soil adjacent to the San Marcos River. Thirty 10 cm peat pots were filled with one of three soil types and placed randomly in a raceway. Water flowed through the raceway at 0.015 m/s from the Edwards Aquifer via an artesian well on the SWT campus. Water depth was 0.4 m. One germinated Texas wildrice seed was placed in each pot. After six weeks growth, plants were harvested. Soil was gently washed from the roots. Plants were returned to the lab and divided into above and below ground parts. Plant material was dried and weighed.

Subsamples of each soil type were shipped to Texas A&M Soil Testing Laboratory for texture, organic matter, and nutrient analysis.

Data were analyzed by single factor ANOVA followed by Tukey Multiple Comparison. Proportional data were transformed by arcsine transformation before analysis (Zar 1984).

RESULTS AND DISCUSSION

On the basis of textural analysis, sediments were designated clay, sandy clay loam, and gravel (Texas A&M Soil Testing Laboratory). Clay was a fine soil, consisting of 62% clay,

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TABLE 1. TEXTURE AND ORGANIC MATTER CONTENT OF THREE SOILS: CLAY, SANDY CLAY LOAM AND GRAVEL, COLLECTED IN AND AROUND THE SAN MARCOS RIVER, SAN MARCOS, TEXAS.

Texture (%)	Clay	Sandy clay loam	Gravel
Sand	3	56	16
Silt	35	23	2
Clay	62	22	3
Gravel	0	0	79
Organic matter (%)	1.7	3.9	0.32

35% silt and only 3% sand. Sandy clay loam, a moderately fine soil, consisted of nearly equal parts silt and clay and 56% sand. Gravel consisted of 79% gravel (particles larger than 2mm), 16% sand and negligible amounts of clay and silt (Table 1). Sandy clay loam had the greatest organic matter content, 3.9%, followed by clay, 1.7% and gravel, 0.32%. Organic matter most likely contributed to the physiological enrichment of the sediments, especially sandy clay loam (Sand-Jensen and Søndergaard 1979).

Soils were analyzed for pH, NO_3, Kjeldahl N, available P, K, Ca, Mg, Z, Fe, Mn, Cu, Na, and S. Soil nutrient concentrations are presented in Table 2. In water, N, P, Z, Mn and Cu coprecipitate and are taken up by the roots (Barko et al. 1991). Of the nutrients which coprecipitate, P and especially N are commonly considered important limiting nutrients for macrophytes (Barko and Smart 1979; Barko et al. 1991). Sandy clay loam had double the Kjeldahl nitrogen concentration of clay, and Kjeldahl nitrogen concentration of gravel was negligible. Available phosphorus concentration was highest in clay followed by sandy clay loam.

Total biomass of plants grown in sandy clay loam (0.790 gm) was significantly greater when compared with plants grown in gravel (0.138 gm) and clay (0.025 gm). Root and shoot biomass were also significantly greater in plants grown in sandy clay loam when compared with plants grown in gravel and clay (Table 3). Nitrogen most likely limited plant growth in gravel and clay sediments. In contrast, phosphorus

TABLE 2. NUTRIENT CONTENT (MG/KG DRY SOIL) OF THREE SOILS: CLAY, SANDY CLAY LOAM AND GRAVEL, COLLECTED IN AND AROUND THE SAN MARCOS RIVER, SAN MARCOS, TEXAS. TEXAS WILDRICE SEEDLINGS WERE PLANTED IN EACH SOIL TYPE.

Nutrient	Clay	Sandy clay loam	Gravel
*NO_3	1	1.3	0.3
*Kjeldahl N	776	1517	71
*Phosphorus	55	47	15
Potassium	335	55	15
Calcium	18893	18413	4830
Magnesium	322	840	225
*Zinc	0.4	2.2	0.6
*Iron	19	83	5
*Manganese	5.6	5.2	1.2
*Copper	1.6	0.8	0.1
Sodium	25	54	17
Sulfur	304	1750	428
pH	8.2	7.8	8.5

*Nutrients which coprecipitate; their source is sediment. All other nutrients are salts which dissolve in water and are most likely taken up by shoots (Barko et al. 1991).

TABLE 3. SHOOT BIOMASS, ROOT BIOMASS, TOTAL BIOMASS (GM/DRY WEIGHT) AND ROOT TO SHOOT RATIO OF TEXAS WILDRICE GROWN IN THREE SEDIMENTS. LETTER FOLLOWING MEAN INDICATES SIGNIFICANT DIFFERENCE USING TUKEY'S MULTIPLE COMPARISON PROCEDURE AT THE 0.05 LEVEL OF SIGNIFICANCE. SD IN PARENTHESIS.

Biomass	Clay	Sandy clay loam	Gravel
Shoot	0.014a[1]	0.616b	0.094a
	(0.006)	(0.205)	(0.043)
Root	0.011a	0.174b	0.044a
	(0.007)	(0.051)	(0.015)
Total	0.025a	0.790b	0.138a
	(0.013)	(0.254)	(0.057)
R:S	0.74a	0.29b	0.50c

[1]Means followed by standard deviation.

was probably not a limiting factor because clay, with the highest phosphorus concentration, produced plants with lowest total biomass.

On infertile sediments, plants allocate more biomass to belowground structures to maximize volume of soil occupied by roots, resulting in relatively high root to shoot ratios (Barko et al. 1991). In this study, however, a different biomass allocation pattern developed than was expected. Plants grown in clay soils (with intermediate nutrient concentration) had the highest root to shoot ratio, 0.74 (Table 3). This suggests plants grown in clay allocate more biomass to below ground parts in an effort to maximize nutrient uptake, and, nutrients, although present in relatively moderate amounts, are inaccessible to plant roots. It is possible small, closely packed clay particles may impede root penetration making nutrients essentially inaccessible for uptake.

Plants grown in the most nutrient depauperate soil, gravel, had an intermediate root to shoot ratio, 0.50. Sandy clay loam, not surprisingly, had a low root to shoot ratio, 0.29 (Table 3). High root to shoot ratio of plants grown in gravel relative to sandy clay loam suggests nutrient limitation on gravel sediments. This may be due to both low nutrient concentration and low nutrient availability because of the greater diffusion distance between gravel particles (Barko and Smart 1986).

In conclusion, high root to shoot ratio of plants grown in clay which had intermediate nutrient concentrations; and, low productivity by plants grown in gravel and clay suggest that soil texture as well as nutrient concentration play an important role in Texas wildrice growth. Plant growth limitation on very fine sediments may be due to textural considerations and on coarse sediments, limitation may be due to nutrient considerations. When selecting sediments for a planting medium for Texas wildrice, either for a conservation population or other purposes, such as reintroduction programs or research projects when high productivity is desirable, coarse, as well as very fine sediments, should be avoided. Sediment selection should focus on moderately fine sediments with high nutrient concentrations.

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