*J. Aquat. Plant Manage.* 29: 99-102

# Ecophenic variations in Wiregrass (*Spatina patens*)

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## ABSTRACT

Wiregrass (*Spartina patens* (Ait) Muhl.) was collected from a Louisiana Gulf Coast brackish marsh. The effect of salinity (5, 15 and 25 ppt) on growth and biomass partitioning was evaluated. Plant height, foliage and root dry weights were reduced at elevated salinity levels. The population from the higher salinity brackish-saltmarsh zone grew better under various salinity regimes as compared to the population from low salinity freshwater-brackish transition zone. Results suggest that there are ecophenic variations in wiregrass which can be exploited in developing superior plants for use in marsh revegetation and coastal restoration projects.

*Key words*: marsh vegetation, salinity stress, population differentiation, marsh restoration.

## INTRODUCTION

There is an increasing demand in the U.S. for wetland plants to be used for marsh restoration and coastal stability projects. Recently the federal government has implemented legislation for preserving national wetlands. When certain wetland areas are destroyed through either commercial or industrial development, a wetland of equivalent size must be established in adjacent areas. This has created a demand for the commercial availability of wetland species. However, physiologically adapted wetland plant sources suitable for specific wetland restoration and environmental conditions are not available in many areas including the U.S. Gulf Coast.

Wiregrass (*Spartina patens* (Ait) Muhl). is a dominant brackish marsh grass in U.S. Gulf Coast marshes which grows over a wide range of salinities ranging from the edge of freshwater habitats (hereafter referred to as freshwater-brackish zone) to saline marshes (hereafter referred to as brackish-salt marsh zone) where it occurs with *S. alterniflora*. Although it is considered as a salt-tolerant species, growth of this species is adversely affected by excess salinity (Parrondo *et. al.* 1978, Gosselink 1984). Field observations along the Louisiana Gulf Coast indicate considerable variations in the performance of populations of this species in response to various salinity regimes.

Under a given environmental stress, evolution of differentiated populations which possess advantageous characteristics has been reported for numerous species

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(Snaydon 1970, Turkington and Harper 1979, Kelley 1979, and Etherington and Thomas 1986). In *S. alterniflora*, several height forms exist which occupy distinct zones in the saltmarshes of the U.S. Atlantic and Gulf Coasts (Nestler 1977, DeLaune *et. al.* 1983, and Pezeshki and DeLaune 1988). Whether these forms are genetically distinct (ecotypes) or homogeneous (ecophenes) has been the basis of much research. Population differentiation is a response to coping with environmental heterogenity (Heslop-Harrison 1964, Ehrlich and Raven 1969, and Hamrick and Allard 1972). For instance, population differentiation has been reported for several saltmarsh species (Gray and Scott 1980, Huiskes *et. al.* 1985, Jefferies *et. al.* 1981, and Boorman 1967). Silander (1985) reported that genotypes of wiregrass from adjacent saltmarsh, swale and dune areas showed evidence of genetic differentiation, but to date, there is little information available in the literature concerning population differentiation of major species in the U.S. Gulf Coast marshes under various levels of salinities (DeLaune *et al.* 1983).

The present study was conducted to evaluate the effects of salinity on growth and biomass partitioning of two U.S. Gulf Coast populations of wiregrass and to identify any ecophenic variations in this species. To evaluate the responses of ecotypes of wiregrass to salinity, distinct phenotypes from a natural range were tested together under uniform conditions (Goodman 1973, and Silander 1985).

## MATERIALS AND METHODS

Population samples of wiregrass were collected from two contrasting sites in coastal Louisiana. Site 1 (Ferblanc) was located near the higher salinity brackish-salt marsh interface zone and site 2 (Clovelly) was located in the northern edge of where wiregrass grows near the freshwater-brackish interface. The predominant salinity average for the Clovely site is 5 ppt, while the Ferblanc population grows under a salinity average of 10 ppt in their natural environment. Sixty to 80 tillers per population were collected, transplanted in a greenhouse, and cloned. Newly germinated culms and associated roots were planted in nursery pots filled with commercial potting soil in a greenhouse. Study pots were watered to excess and fertilized (0.05 g $pot^{-1}$) with a commercial water soluble fertilizer (23-19-17, N, P, K, respective percentages) once per week. Two weeks after transplanting, salinity treatments were initiated.

Salt solutions were prepared using Instant Ocean Synthetic Sea Salt (Aquarium Systems, Inc., Mentor, Ohio, USA), with major ionic components of 47% Cl, 26% Na, 6% $SO_4$, 3% Mg, 1% Ca and 1% K (percentage of dry weight). Treatments began by flooding the pots with 1 part per 1000 (17 mol $m^{-3}$) salt on the first day. The salinity concentration for the first treatment ($T_1$) was then increased to 3 ppt on the 3rd day and to 5 ppt on the 7th day of the experiment. The second treatment ($T_2$) consisted of salinities which were added at the same rate as in $T_1$ except that salinity was increased to 10 ppt on day 8 and to 15 ppt on day 10. In the third treatment ($T_3$), plants were subjected to salinity levels in the sequences described except that salinity increased to 10 ppt on day 8, 15 ppt on day 10, 20 ppt on day 12 and 25 ppt on day 15. A YSI model 33 meter (Yellow Springs Instrument Co., Yellow Springs, Ohio, USA) was used to measure salt concentrations in all pots throughout the experiment. Throughout the study, pots were drained once a week and freshly made salt solution (at respective concentrations) and fertilizer was reapplied. Treatments $T_1$ and $T_2$ represent the range of salinity encountered by these populations. The highest salinity treatment (T3) allowed the evaluation of both populations under elevated salinity condition.

The experimental design was a completely randomized block design with 2 populations, 3 salinity treatments and 54 replications (pots) per population/salinity combination. Each container consisted of one plantlet which subsequently reproduced new culms.

Changes in biomass were evaluated from replicated destructive samples taken weekly from each population-treatment combination using random tables. The weekly samplings were conducted between week 1 through 8. At each weekly sampling interval, 6 pots per population per treatment were destructively sampled, washed and divided into above- and below-ground components. Final biomass sampling was taken during the 10th week. Leaf surface area (LA) was determined using a Leaf Area Analysis System (SI-701, SKYE Instrument, Inc., Buckingham, PA). Biomass samples were then oven dried at 70 C to a constant weight and dry weights were recorded.

Mean values of variables were compared between populations within each treatment using t-test procedures of Statistical Analysis System (SAS, SAS Institute, Carry, NC). The General Linear Models (GLM) and Least Significant Difference (LSD) of SAS were used to compare means for each population among the salinity treatments.

TABLE 1. AVERAGE RESPONSE OF TWO POPULATIONS OF *SPARTINA PATENS* TO ELEVATED SALINITY TREATMENT COMPARED USING GLM AND DUNCAN'S MULTIPLE RANGE TEST PROCEDURES OF SAS. DATA WERE COLLECTED DLURING THE LAST WEEK OF THE EXPERIMENT(10TH). VALUES IN HORIZONTAL SEQUENCE NOT FOLLOWED BY THE SAME LETTER ARE SIGNIFICANTLY DIFFERENT AT 0.05 LEVEL. PRE-TREATMENT VALUES REPRESENT AVERAGE (PER POPULATION) MEASURED AT THE INITIATION OF THE EXPERIMENT. *REPRESENT SIGNIFICANT DIFFERENCES ($P \leq 0.05$) FOR THE PRE-TREATMENT VARIABLE BETWEEN POPULATIONS.

| | | | Treatment | | |
|---|---|---|---|---|---|
| Population | Variable | pre-treatment | $T_1$ | $T_2$ | $T_3$ |
| Ferblanc (site 1) | Height (cm) | 20.7 | 34.4 a | 28.7 b | 22.2 c |
| | no. of leaves | 37.6 | 77.7 a | 56.0 b | 47.4 b |
| | no. of culms | 13.1* | 32.6 a | 24.1 b | 21.2 b |
| | Foliage Dw (g) | 2.9 | 20.7 a | 12.1 a | 7.2 b |
| | Root Dw (g) | 0.89 | 7.3 a | 3.9 b | 2.5 b |
| | Leaf area ($m^2$) | 0.01 | 0.14 a | 0.09 b | 0.05 c |
| Clovelly (site 2) | Height (cm) | 22.1 | 36.6 a | 27.5 b | 25.6 b |
| | no. of leaves | 31.1 | 58.5 a | 53.1 ab | 40.7 b |
| | no. of culms | 8.6 | 20.3 a | 18.9 a | 14.6 b |
| | Foliage Dw (g) | 3.2 | 13.5 a | 9.5 ab | 7.2 b |
| | Root Dw (g) | 0.76 | 4.0 a | 3.3 ab | 1.9 b |
| | Leaf area ($m^2$) | 0.01 | 0.10 a | 0.10 a | 0.05 b |

## RESULTS AND DISCUSSION

Both populations survived the salinity treatments imposed in this study. However, the salinity increase from $T_1$ to $T_2$ and $T_3$ reduced height and biomass of Ferblanc plants significantly (Table 1). For example, foliage dry weight was reduced by 42% and 65% in $T_2$ and $T_3$ as compared to $T_1$, respectively. Root dry weight per pot was reduced 47% and 66% in $T_2$ and $T_3$, respectively. Similarly, plant height, as well as biomass were significantly reduced in Clovelly population in response to the elevated salinity treatments (Table 1). Ferblanc maintained greater foliage dry weight ($p = 0.0150$) and root dry weight ($p = 0.0176$) in T1 as compared to Clovelly. Leaf area per pot was also reduced in response to elevated salinities in both populations (Table 1). Neverthless, in $T_1$ treatment, Ferblanc maintained significantly greater LA ($p = 0.0154$) as compared to Clovelly. Under all treatments Ferblanc produced more new vegetative culms than Clovelly, indicating a potential advantageous characteristic. For example, in the T3 treatment, the average number of new vegetative culms was 21.2 and 14.6 in Ferblanc and Clovelly, respectively. This difference was statistically significant ($p = 0.0085$).

Biomass production was reduced by increasing salinity treatments in both populations. However, with progression of the study, the Ferblanc population maintained greater biomass compared to the Clovelly population. This difference was more pronounced in $T_1$ and $T_2$ than in $T_3$ as shown by significant t-test differences.

Changes in biomass parameters are illustrated in Figure 1. Results are presented as change in a given parameter calculated as percentage of biomass values obtained during the first harvest for respective population-treatment combination under different treatments. Increases in salinity resulted in reductions of height, foliage dry weight and total dry weight in both populations (Figure 1). However, percent changes in foliage dry weight and total dry weight was substantially greater in the Ferblanc population than in the Clovelly population under all salinities (Figure 1).

In the present study, both populations survived the salinity treatments over 10 weeks. However, reductions in growth and biomass production in response to salinity treatment were evident. Salinity responses observed were in agreement with field observations showing the relative position of the two populations in the natural range of wiregrass. Ferblanc population is associated with saltmarsh-brackish marsh interface where soil salinity is greater than brackish-freshwater transition zone where Clovelly population were collected. Overall, there was evidence of differences in salt-tolerance, as well as of growth patterns of the study populations. Ferblanc population grows faster than Clovelly population under various salinity regimes (Figure 1). Such findings are important from the practical point of view because of the potential for selection of stress tolerant plant populations at subspecies level. Identification of genetically distinct strains which are tolerant to elevated salinities is useful in developing strategies for stabilization and revegetating of deteriorating marshes. However, traits such as height, leaf area and culms regeneration are closely associated with competitive characteristic, which are traits influencing differential genetic success in different environments (Silander, 1985). Consequently, selection of one genetic strain alone would not be acceptable for use in revegetating various wetland sites which may differ in soil physicochemical characteristics. For instance, populations could be selected from sites that match conditions at potential revegetation sites, and clones could be cultured for particularly extreme salinity conditions.

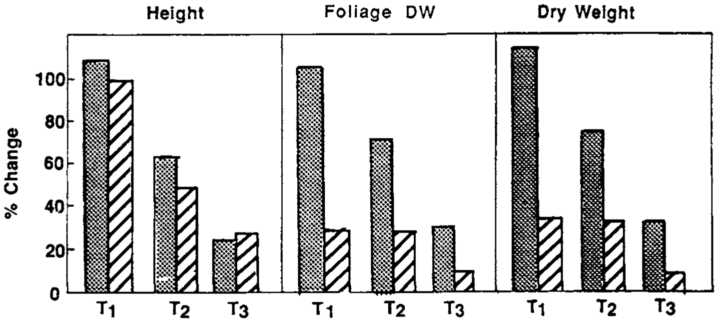

Figure 1. Percent changes in height, foliage dry weight (DW) and total dry weight (foliage and root) in two populations of *Spartina patens*, Freblanc (dotted bars) and Clovelly (hatched bars) under various salinity treatments. Data were collected during the last week of the experiment (1oth week) and were compared with the data of first harvest for respective population-treatment means.

The success of marsh restoration projects is governed by many factors. Selecting the physiologically adapted plant species for wetland creation and restoration basically involves the matching of plant species with wetland conditions. Such conditions include degree of flooding, salinity, and soil substrate (e.g. mineral sediment, organic matter relationships). Coastal vegetation in the U.S. Gulf coast is primarily composed of grasses, sedges and other herbaceous angiosperms. Along the U.S. Gulf Coast *S. alterniflora* and *S. patens* are the dominant marsh species which have been used extensively in marsh planting efforts in different coastal areas (Woodhouse *et al.*, 1974, 1976). Results suggest the need for future evaluation of these and other populations of wiregrass under both laboratory/greenhouse experiments as well as field *in situ* transplanting to further evaluate and compare performance of these populations under field conditions.

## ACKNOWLEDGEMENT

Funding for this project was provided by the Louisiana Education Quality Support Fund, Project No. LEQSF (1987-90)-RD-A-7.

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